Twenty-four-hour, weekly and annual patterns in serious falls of non-institutionalized independent Spanish seniors

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Abstract. – OBJECTIVE: The study aimed to explore clock hour, day-of-week, and month-of-year patterns of serious falls experienced by non-institutionalized Spanish seniors (age ≥65 years) in relation to associated conventional intrinsic and extrinsic factors.

PATIENTS AND METHODS: Intake emergency department records from January 1 to December 31, 2013 of a tertiary hospital of southern Spain were abstracted for particulars of falls, including the time of occurrence, experienced specifically by non-institutionalized seniors. Chi-squares and Single and Multiple-Component Cosinor (time series) Analyses were applied to determine the statistical significance of observed 24-hour, 7-day, and annual variation.

RESULTS: Falls were ~2.5-fold more numerous in older women than older men and ~7-fold more frequent between 12:00 and 14:00 hours than ~02:00 hours, respectively, the time spans corresponding to the absolute peak and trough of the 24-hour pattern in falls. The midday/early afternoon peak primarily represented incidents of women ≥75 years of age that occurred inside the home while walking, standing, or moving on stairs. A late evening less prominent excess of mostly inside-the-home incidents of women ≥75 years of age, largely due to fragility, slipping, stumbling, or tripping, was additionally detected. Cosinor Analysis substantiates statistical significance of the 24-hour patterning of falls of men and women (both *p*<0.001). Day-of-week differences, with prominent Thursday peak and Sunday minimum, were additionally detected, but only for falls of women occurring outside the home (Cosinor Analysis: *p*=0.007). Day-of-week discrepancy in female/male sex ratio (SR) of fallers was demonstrated, arising from day-of-week disparity in the SR of inside-the-home incidents, with ~4.5-fold more elderly women than elderly men falling Thursday than any other day of the week (*p*=0.005). Non-statistically significant month-of-year difference in falls, lowest in autumn and highest (~60% more) in winter, was observed and explained by prominent seasonal difference in incidents by elderly women.

CONCLUSIONS: Serious falls of non-institutionalized independent seniors are characterized according to intrinsic and extrinsic factors by prominent 24-hour and 7-day patterning. These findings complement the understanding of the epidemiology of falls of the elderly and further inform fall prevention programs.

Key Words:
Elderly, Domestic falls, Time-of-day, Day-of-week, Month-of-year, Sex differences, Fall epidemiology.

Introduction

Preservation of the independence of seniors today is a major public health goal as the number of persons surviving beyond 65 years (y) of age continues to significantly increase. Falls are the most frequent and serious mishaps experienced by the aged and constitute the main reason, even in the absence of serious injury, for the hospitalization, institutionalization, and loss of independence of the elderly[1-3]. Epidemiological studies reveal one of every three community (non-institutionalized) residing seniors experiences a fall annually[1], with fall incidence approaching 50% among those from 70 to 80 y of age[4].

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Previous investigations have identified both intrinsic (specific to faller) and extrinsic (specific to faller's milieu) fall risk factors[3,5,6]. Such information is often solicited by personnel of hospital emergency departments and included into patient medical records. The knowledge of these factors enables appropriate perspective of the epidemiology of falls to inform and improve prevention programs, since according to Yates and Dunnagan[7] (2001) the elimination even of one risk factor can significantly reduce incidents and consequent trauma. The environment in which a fall happens typically reflects associated intrinsic and extrinsic factors, including precipitating circumstances. For example, falls of seniors confined to a hospital or institution, compared to those who independently reside in their home, entail factors of inadequate oversight by healthcare personnel and fragility of chronic or acute illnesses[8].

A commonly neglected factor of potential relevance to fall epidemiology and prevention programs is the time of incidents. Prominent time-of-day (perhaps more appropriately termed circadian-time-dependent) patterns are evident in the occurrence of acute life-threatening cardiovascular events and exacerbation of a wide range of chronic medical conditions[9,10], and this knowledge has informed new innovative therapeutic approaches, i.e., chronotherapeutic[11-19]. We believe the 'time of fall' is a critical epidemiology variable, since an increasing number of reports reveals fall events do not occur at random, but rather there exists "windows" during the 24 hours (h), week, and year when they are more likely[20-40]. Thus, we recommend epidemiologic investigations include the clock hour, day of week, and month of year of every fall incident and their analysis, in relation to individual intrinsic and extrinsic factors, by appropriate time series methods[41]. By using this approach, we previously found prominent time-of-day and other temporal differences in fall numbers of hospitalized seniors that were linked with time-of-day patterns in patient routine and healthcare personnel work load and schedule[32,34]. However, a recent systematic review[35] by one of our authors found that the time of fall by hospitalized individuals was registered in only ~50% of patient medical records.

Surprisingly, few investigations[22,25,27-30,36,38-40] have explored temporal patterns in community falls of non-institutionalized elderly, and the majority of these concerned monthly or seasonal differences in incidents resulting in hip and other fractures. Only a very small number of them addressed time-of-day differences of incidents experienced by independently residing seniors[20,23,37,42], and even a smaller number assessed day-of-week differences[23,37]. Herein, we report findings related to temporal patterns in serious falls experienced by independently residing Spanish seniors who required hospital emergency department medical evaluation and care. Based on previous published findings, we suggested such falls would be most frequent in occurrence during the morning, weekend, and winter.

Patients and Methods

Setting and Population

The study was approved by the Institutional Ethics Committee for Human Investigations of the Province of Cordoba, Spain. The study site, which is situated in the north-central part of the southern Spanish region of Andalusia, had a population of 328,373 residents in the year in which the data are representative. The source of data was the medical records of the Accidents and Emergency Unit Services (AEUS) of a regional tertiary level hospital where elderly fallers were transported for evaluation and/or care for fall injury between January 1 and December 31, 2013.

Case Definition

A fall is defined as proposed by the World Health Organization, i.e., "an event that results in a person coming to rest inadvertently on the ground or floor or lower level" (http://www.who.int/mediacentre/factsheets/fs344/en/). The primary qualifying criterion of data inclusion and analysis was certainty the fall involved an independent residing senior not domiciled in a healthcare or other institutional facility. Other criteria for inclusion were: (1) transport to study hospital AEUS for observation or treatment the same day as fall occurrence; (2) age ≥65 y; and (3) medical record listing exact clock hour or day of week or calendar date of incident. Exclusion criteria were: (1) medical event not matching definition of fall; (2) faller not transported to study hospital AEUS; (3) transport to hospital AEUS a different day than fall occurrence; (4) medical record not listing residential location of fall or listing it as hospital, nursing home, or other non-independent-living institutional setting; (5) medical record not or imprecisely listing clock time, i.e., missing it entirely or stating it qualitatively as morning, afternoon, evening, or night; (6) age

<65 y; and (7) repeat falls of the same person, for which only data of the first fall event of the study year were qualified for inclusion. Falls by independently residing seniors whose medical records accurately listed day-of-week and/or month-of-year of occurrence, even if lacking or being imprecise for clock time, were qualified for corresponding temporal pattern analyses. Almost all medical records were complete for patient's sex, age, medical history and conditions, prescribed and over-the-counter medications, and discharge destination. It also listed location, cause, mode (activity/position), and consequences of the fall. Clock hour of fall occurrence was either that provided by the patient, time of arrival to the AEUS, or time of dispatch of ambulance. For the year of data collection, the response time between the receipt of a call for ambulance and arrival to destination to provide emergency service averaged 9 minutes and 23 seconds. The falls were sorted by clock hour, day of week, month, and season [spring (March 1 – May 31), summer (June 1 – August 31), autumn (September 1 to November 31), and winter (December 1 – February 28)] of occurrence. Incidents were additionally classified according to location where they happened, inside or outside the home, i.e., street, or other sites, such as store, doctor's office, etc. Cause was categorized as slip, stumble/trip, fragility, syncope, or accident (unknown trigger). Mode – body position/activity – of fall was categorized as upright while standing, walking, or moving on stairs; moving from (rising/sitting) or through furniture; bathroom toileting, bathing, or grooming; or other. Hospital discharge was categorized as either to one's own residence, care institution, or funeral home. Death and number of days of hospitalization were used as measures of fall severity. The medications were categorized according to their potential for contributing to fall risk, that is, according to known adverse effects on vigilance, cognition, balance, and consciousness.

Statistical Analysis

Descriptive and inferential analyses were performed with IBM Statistical Product and Service Solution (SPSS) version 21 software (IBM Corp., Armonk, NY, USA). Data were sorted by sex and age of faller and cause, mode (activity/position), location, and circumstances of fall incident. Clinical and sociodemographic variables are described by numerical values and percentages, and statistical comparisons are performed by contingency table tests. The chi-squares test is used to assess unequal day-of-week and month-of-year distribution of senior falls. Cosinor Analysis[43,44] is utilized to objectively determine statistical significance of observed sinusoidal-like shaped 24-h, 7-day (d), and 1-y patterns. This analysis applies cosine waveform(s) of specific trial period(s), the fundamental (and its harmonics accomplished using Multiple-Component Cosinor Analysis, when the curve of the temporal pattern deviates markedly from the simple cosine model) by the least-squares method. Statistical significance is accomplished by F-test of the variance explained by the best approximating waveform *vs.* that explained by the straight line fit to the time-series data; essentially, this is a test of the null hypothesis the amplitude value of the temporal pattern of a given period (τ), i.e., 24-h, 7-d, or 1-y, is zero. Statistical significance is assumed when the null hypothesis of zero amplitude is rejected with $p < 0.05$. The percentage of total variance (PR) represented by the approximated cosine function per designated τ is a goodness of fit parameter; PR ranged between 40 to 60% for the vast majority of the Cosinor Analysis-verified statistically significant temporal patterns. When statistical significance is substantiated for a given τ, descriptive parameters derived from the best fitting waveform are the time series mean, amplitude (one-half the peak-to-trough variation), and peak time. Peak time is expressed for 24-h, 7-d, and 1-y temporal patterns, respectively, relative to local midnight (00:00 h), 00:00 h Sunday, and 00:00 h December 31. Graphs of falls depicting 24-h patterns show data per 2-h interval, even though Cosinor Analysis incorporated hourly values.

Results

Sample Characteristics

There were 39,293 hospital admissions to the tertiary hospital during the 2013 study span, of which 888 (2.3%) were for serious falls by seniors. However, 395 of them failed to satisfy inclusion criteria, either because medical records: (1) did not list location of the fall (N = 310) or listed it as an institutional setting (N = 66), (2) revealed the fall to be one of several by the same senior during the 2013 study year (N = 13), or (3) lacked data of sex or age (N = 6), thereby leaving 493 cases for analysis. The medical records of 81 of these 493 (83.6%) fallers lacked or imprecisely registered the clock hour of fall, but properly designated the day of week and month of year of occurrence. Thus, the time-of-day analyses entailing intrinsic and extrinsic fall factors are based on N = 412 cases, and day-of-week and month-of-year analyses N = 493 cases. The circumstances and demographic details of the 412 senior falls for which the clock time of occurrence was reliably known are summarized in Table I. The proportion of female fallers (71.6%) was significantly larger ($p < 0.005$) than male fallers (28.4%). The mean age (±SE) of fallers was 81.4 (±7.6) y, with significant difference ($p = 0.012$) between women (82.0 ± 7.5 y) and men (79.9 ± 7.7 y). The most prevalent chronic medical conditions of the senior fallers were arterial hypertension (64.8%), diabetes mellitus (30.6%), dyslipidemia (24.3%), and circulatory system disorders (18.9%); 37.4% of fallers had medical history of a cardiovascular event. Some 68% took ≥5 medications daily; the mean number (±SE) being 6.6 (±3.9), without difference between males and females. Antihypertensive (57.5%), such as the calcium channel blockers verapamil and diltiazem and angiotensin converting enzyme inhibitors enalapril and captopril, anticoagulant (49.5%), and lipid-modifying (31.8%) medications were most prevalent. Most (79.1%) falls happened inside the home and only 19.4% outside but in the immediate vicinity of the home; the remainder (1.5%) occurred elsewhere – store, doctor's office, etc. Information pertaining to the mode of fall was absent from 32.0% of the medical records. Records complete for this extrinsic factor indicate a substantial proportion (33.3%) of incidents happened inside the home when the senior was in an upright position standing or walking. The second and third most frequent modes were, respectively, inside the home when ascending/descending stairs (11.2%) and moving to/from a seated position (9.0%). Only 4.9% of falls occurred when repositioning from furniture, and only 2.2% were associated with bathroom activities. The most common cause of a fall was an accident of some type (65.5%), followed by syncope (13.1%), stumbling/tripping (10.9%), slipping (4.9%), and fragility (2.4%); other miscellaneous causes made up the remainder (3.2%). 7.0% of fallers died from the consequent trauma. Although fall-associated mortality was higher in men than women, the difference in number of deaths by sex of faller was not statistically significant ($p = 0.38$). The average (±SD) duration of hospitalization was 8.6 (±6.0) d, without sex difference ($p = 0.45$). Duration of hospitalization was 2 to 7 d for 44.9% (7.0% died), 8 to 14 d for 39.1%

Table I. Demographic and circumstances of the 412 senior falls for which study inclusion criteria of location and clock hour of occurrence are satisfied.

Variable	Total (N = 412)	Male (N = 117)	Female (N = 295)
Age	81.4 ± 7.6	79.9 ± 7.7	82.0 ± 7.5*
Place of fall			
Home	326 (79.1%)	90 (76.9%)	236 (80.0%)
Outside/Street	80 (19.4%)	25 (21.4%)	55 (18.6%)
Other	6 (1.5%)	2 (1.7%)	4 (1.4%)
Mode of fall			
While walking/Standing	137 (33.3%)	43 (36.8%)	94 (31.9%)
Standing/Sitting	37 (9.0%)	6 (5.1%)	31 (10.5%)
Bathroom/On toilet	9 (2.2%)	4 (3.4%)	5 (1.7%)
From furniture	20 (4.9%)	5 (4.3%)	15 (5.1%)
On stairs	46 (11.2%)	15 (12.8%)	31 (10.5%)
Trip	19 (4.6%)	4 (3.4%)	15 (5.1%)
Other mode	12 (2.9%)	4 (3.4%)	8 (2.7%)
Unknown	132 (32.0%)	36 (30.8%)	96 (32.5%)
Number of medications	6.6 ± 3.9	6.5 ± 3.5	6.6 ± 4.1
Cause of fall			
Accident	270 (65.5%)	71 (60.7%)	199 (67.5%)
Syncope	54 (13.1%)	21 (17.9%)	33 (11.2%)
Stumbling/Tripping	45 (10.9%)	10 (8.5%)	35 (11.9%)
Slipping	20 (4.9%)	9 (7.7%)	11 (3.7%)
Fragility	10 (2.4%)	3 (2.6%)	7 (2.4%)
Other	13 (3.2%)	3 (2.6%)	10 (3.4%)

*$p = 0.012$.

(2.5% died), and ≥15 d for 10.6%. Overall, one of the three patients hospitalized for ≤1 d for trauma experienced by the fall incident died, presumably due to excessive fall severity and/or faller fragility.

Temporal Patterns

24-Hour Pattern of Falls

Figure 1 depicts the distribution per 2-h interval of the 412 falls for which the clock time of their happening is known. The individual graphs (A-F) respectively portray the time-of-day distribution of falls according to sex and age of faller and location, mode (position/activity), and cause.

Graph A of Figure 1 presents the time-of-day differences in number of falls of senior women (N = 295) and men (N = 117) separately and combined. Incidents by women and men combined are ~7-fold more frequent between 12:00 and 14:00 h than at ~02:00 h, respectively, the major peak and trough of the 24-h pattern. There is a slight decline in total fall number in the early afternoon, perhaps related to the common midday siesta in southern Spain, and an increase to a second somewhat less prominent peak at ~22:00 h. The high-amplitude day/night difference in fall number of senior women, who experienced the majority of events, is similar. The time-of-day distribution of falls by men is somewhat different; it is characterized by a plateau of relative excess between late morning and early evening and without late evening excess. Cosinor Analysis of the hourly data substantiates statistically significant 24-h variation in fall occurrence of men and women combined, as well as men alone and women alone ($p < 0.001$ all cases).

Graph B of the Figure displays the clock-time variation in fall number for the age categories of 65-74, 75-84, and 85^{+} y. The overall features of the respective curve pattern of each age group are similar. Incidents are lowest, as a trough, overnight and highest, as a prominent peak, between midday and mid-afternoon, with a secondary peak early or late evening. The amplitude of the temporal variation is appreciable. Cosinor Analyses substantiate significant 24-h variation in the fall number for all three age groups ($p < 0.001$ all cases). Location of fall was registered in the medical records of all fallers. Graphs C and D portray the clock-hour disparity in fall number according to site of occurrence, respectively, of elderly women and men. Many more falls of females take place inside than outside the home. Fall occurrence both inside and outside the home is higher during the daytime activity span than overnight sleep span. The ~10:00 h peak time of the outside-the-home fall curve is earlier than the ~14:00 h peak time of the inside-the-home one. Moreover, the amplitude of variation (difference in number of incidents between the trough and most prominent peak) is greater for the inside than the outside-the-home curve. A second evening ~22:00 h peak of almost equal magnitude as the primary one at ~14:00 h is evident in the temporal pattern of outside-the-home falls, while the secondary ~22:00 h peak of that of inside-the-home falls is considerably less prominent. The plot of inside-the-home falls of men showed in Graph D exhibits two major peaks, the first around midday and second in late afternoon. The curve of outside-the-home falls of men evidences three peaks – early afternoon, late afternoon, and late evening. Cosinor Analysis reveals statistically significant 24-h variation in inside-the-home incidents of men and women combined and women and men separately ($p < 0.001$ in all cases). Cosinor Analysis also substantiates such temporal variation for falls that take place outside the home of women and men combined ($p = 0.011$) and for men ($p = 0.035$), but not women ($p = 0.17$). Mode (position/activity) of fall was registered in the medical record of 199 (67.5 %) women and 81 (69.2 %) male fallers. Graph E of Figure 1 displays the clock-time variation in the most common mode of falls (total N = 183) upright position while standing/walking (N = 137) plus moving on-stairs (N = 46), and the second most common one (total N = 57) arising/sitting (N = 37) plus falling from furniture (N = 20). The high-amplitude curve of the first category exhibits an overnight trough at ~02:00 h and prominent midday 12:00 h peak. The considerably lower-amplitude curve of the second category is characterized also by an overnight trough at ~02:00 h, but the crest time is different, being late afternoon/early evening, i.e., 18:00-20:00 h. Cosinor Analysis documents statistically significant time-of-day difference in both mode categories – upright position while standing, walking, and moving on-stairs ($p < 0.001$) and moving through and ascending from or descending upon furniture ($p = 0.004$).

Cause of fall was listed in every medical record. Graph F of Figure 1 presents the time-of-day differences of elderly falls by cause, categorized either as an accident (65.5%), combination

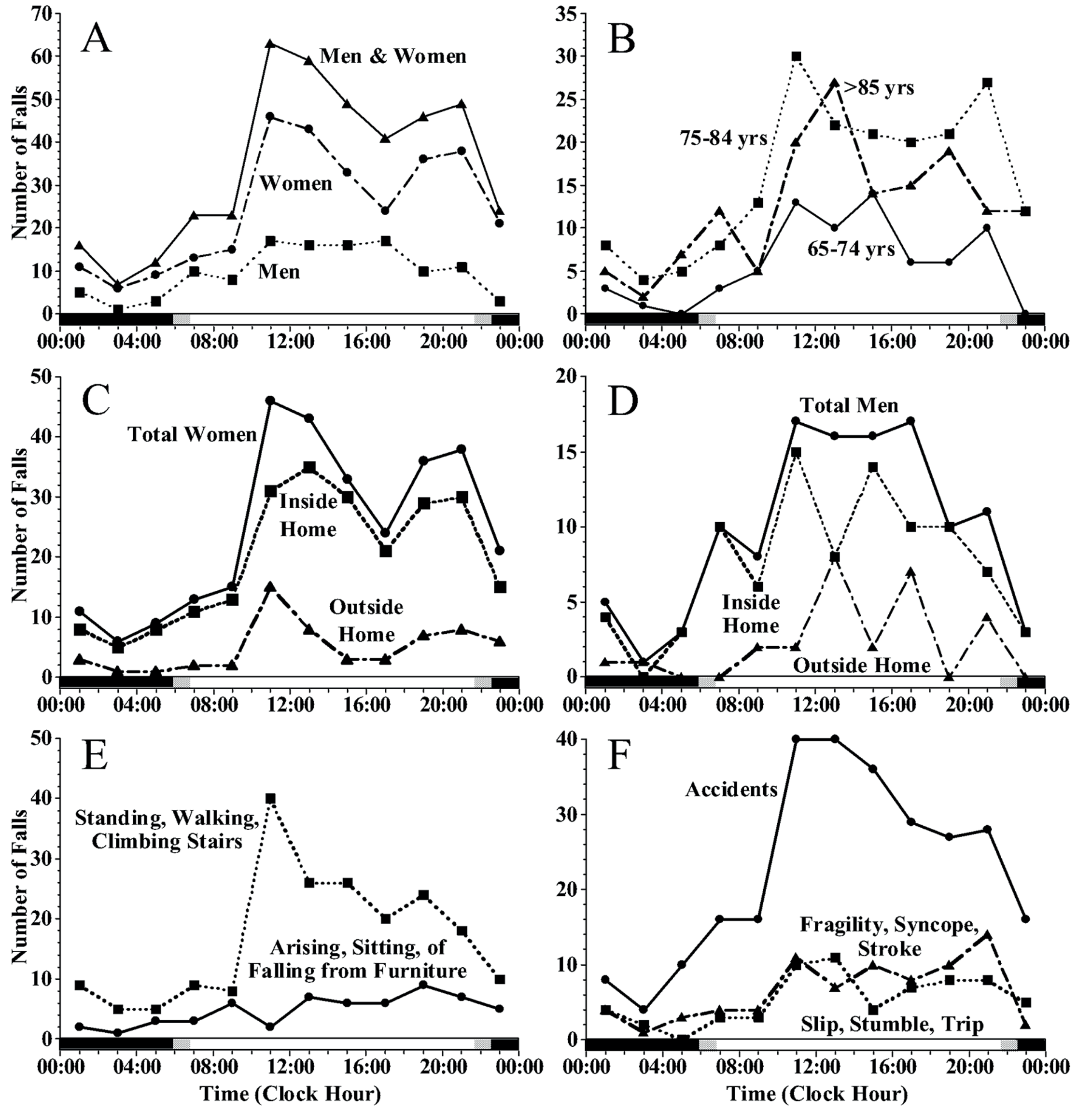

Figure 1. Time-of-day variation in occurrence of serious falls of independently residing Spanish seniors presumably adhering to a routine of nighttime sleep (~23:00-06:30 h, indicated by shaded portion of horizontal axes), and daytime activity (~06:30-23:00 h, indicated by non-shaded portion of horizontal axes). **A,** Sex of faller: the high-amplitude 24 h pattern of falls by women is characterized by two – midday/early-afternoon more prominent and late-evening somewhat less prominent – peaks and single major trough at ~02:00 h. The comparatively lower amplitude curve for men exhibits a plateau of falls between midday and early evening and trough at ~02:00 h. **B,** Age of faller: the major peak of falls is similar, ~midday, across the three (≥65-74 y, 75-84 y, and 85^+ y) age categories; a second relatively prominent evening/late-night peak is additionally evident in all age groups. **C,** Location of falls by women: the high-amplitude 24 h pattern of *inside-the-home* falls of women closely resembles that of total fall number of women reproduced in the graph from Graph A; it displays two – midday/early-afternoon more prominent and single late-evening somewhat less prominent – peaks and major trough at ~02:00 h. The pattern of *outside-the-home* falls by women reveals incidents are uncommon overnight and prevalent midday and to lesser extent evening. **D,** Location of falls by men: inside and outside-the-home fall 24 h patterns are both characterized by multiple peaks and troughs, but with an overall much greater fall number around midday and late afternoon; the inside-the-home temporal pattern of men additionally depicts minor excess of incidents at ~02:00 h. **E,** Body position/activity associated with fall: falls occurring when upright while walking, standing, and moving on stairs happen in greatest number ~12:00 h and lowest number overnight and initial hours of diurnal activity. The low-amplitude 24 h pattern of falls associated with sitting and arising from furniture is characterized by a daytime somewhat elevated plateau, with absolute early-evening peak. **F,** Cause of fall: the peak of the high-amplitude 24 h pattern of falls caused by an accident (non-specific cause) is between 12:00-14:00 h and trough at ~02:00 h. The lower-amplitude patterns of the combined cause categories of (1) fragility, syncope, and stroke and also (2) slip, stumble, and trip display two minor peaks – midday and evening – and absolute trough at ~02:00 h.

of fragility, syncope, or stroke (17.4 %), or combination of slip, stumble, or trip (16.3 %). Like most curves displayed in Figure 1, the high-amplitude temporal variation in falls caused by an accident exhibits a trough at ~02:00 h and very prominent single 12:00-14:00 h peak. The time-of-day plot of the two other cause categories is characterized by early-afternoon and evening double peaks. Cosinor Analysis substantiates statistically significant clock-hour difference of falls caused by an accident ($p < 0.001$) and by fragility, syncope, or stroke as a combined category ($p = 0.005$), and near statistical significance of those caused by slip, stumble, or trip as a combined category ($p = 0.056$). It is of interest that additional Cosinor Analyses verify time-of-day differences in falls caused specifically by syncope ($p = 0.007$), with a peak time of ~16:00 h, but not specifically by fragility ($p = 0.36$) or stroke ($p = 0.20$).

Day-of-week Pattern of Falls

A total of 493 medical records listed day of week of the fall; 350 of them happened on the weekdays (Monday through Friday), and 143 happened on weekend days (Saturday and Sunday). Figure 2A shows that the total number of male plus female incidents occurring on weekdays increases progressively from Monday to Wednesday, when fall number is highest, and decreases thereafter, Thursday and Friday. However, weekday incidents of women and men are most frequent, respectively, Thursday and Wednesday, and least frequent, respectively, Friday and Thursday. The total, i.e., women plus men, number of weekend falls is greatest Saturday, primarily due to the absolute peak occurrence of events this day of the entire week by women. Falls happen in the lowest number on Sunday, primarily due to the very small number of falls experienced by women this day of the week. Although Chi-squares tests do not verify statistical significance of any of the above discussed day-of-week differences in fall number ($p > 0.15$), Cosinor Analysis substantiates 7-d sinusoidal-like patterning of incidents of women that happen outside the home ($p = 0.007$), with peak number on Thursday, but not for ones that occur inside the home ($p > 0.50$). Moreover, Cosinor Analysis does not detect 7-d patterning in falls by men that take place either inside or outside the home or for the two categories combined ($p > 0.48$), or in the total number of falls inside plus outside the house by both sexes combined ($p > 0.50$).

Figure 2B additionally depicts the day-of-week fall data in terms of the female/male sex ratio, SR. SR exhibits a prominent Thursday peak that is ~2.5-fold greater than any other day of the week due to a greater number of incidents,

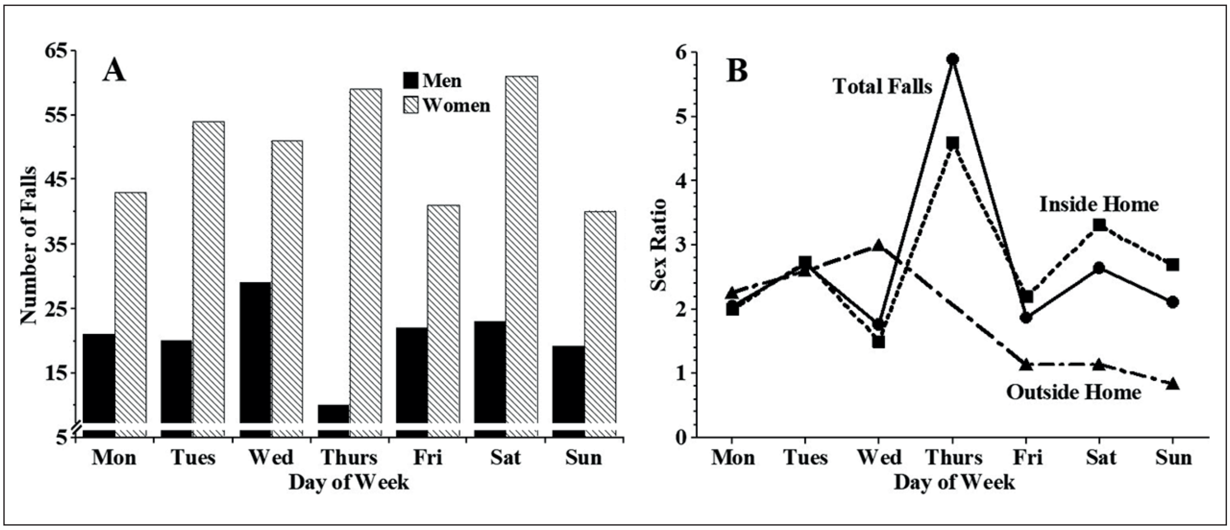

Figure 2. Day-of-week variation of serious falls of independently residing Spanish seniors. **A,** Number of falls shown separately for women and men by day of the week. Falls weekdays are most frequent by women and men, respectively, on Thursday and Wednesday, and least frequent, respectively, Friday and Thursday. However, the absolute peak number of falls by women is Saturday. **B,** Day-of-week difference in (female/male) sex ratio (SR) of senior fallers. The overall SR is many-fold greater Thursday compared to all other days of the week principally due to the many fold higher SR of inside-the-home fallers that day. The day-of-week SR pattern for outside-the-home falls displays a Wednesday peak and Sunday trough, when falls by women happen in lower number than by men.

compared to any other day of the week, by elderly women than elderly men. Figure 2B also shows the considerably greater day-of-week disparity in the SR of inside *vs*. outside-the-home falls. In particular, ~4.5-fold more women than men experience incidents inside their residence Thursday and ~3-fold more women than men experience them inside their residence Saturday. There is also substantial day-of-week difference in the SR of outside-the-home falls. On average, more than twice as many women than men have serious incidents outside the home Monday through Wednesday, while Friday through Sunday men and women essentially have them outside the home in equal number. Overall, serious inside-the-home falls are ~4.5-fold more frequent in women than men Thursday when outside-the-home ones are very much less frequent in women than men. Nonetheless, Cosinor Analyses do not substantiate 7-d sinusoidal-like patterning in the SR of fallers independent of location of incident occurrence ($p > 0.50$) or of incidents happening inside ($p > 0.50$) or outside ($p \sim 0.10$) the home.

Month-of-Year Pattern of Falls

A total of 493 medical records were protocol correct for calendar date and time-of-year analyses. Figure 3A illustrates the appreciable month-to-month variation in falls separately for senior men and women. The proportion of the total (male + female) number of falls is higher than average, i.e., 8.33% assuming equal distribution across each of the 12 months, January (10.95%), February (10.75%), and July (10.75%), and lower than average April (7.1%), August (6.29%), and September (4.26%). Chi-squares tests reveal between-month difference in the distribution of total fall number of senior men and women combined ($p < 0.02$). Between-month difference in inside-the-home ($p < 0.003$), but not outside-the-home ($p > 0.50$), falls of women is also substantiated. In contrast, no such between-month disparity is detected in falls by men happening inside ($p = 0.47$) or outside ($p = 0.09$) the home.

The total number of incidents of senior men and women combined exhibits seasonal variation ($p = 0.02$), being lowest during autumn (September-November: N = 97 [19.7%]), highest during winter (December-February: N = 146 [29.6%]), and intermediate during spring (March-May: N = 124 [25.2%]) and summer (June-August: N = 126 [25.6%]). Falls of elderly women exhibit larger seasonal variation, i.e., N = 111 in winter *vs.* N = 67 in autumn ($p = 0.01$), than elderly men, i.e., N = 41 in summer *vs.* N = 30 autumn ($p > 0.50$). The vast majority of incidents of both elderly women and men happen inside the home, respectively, 79.7% and 76.4%. Such incidents of women ex-

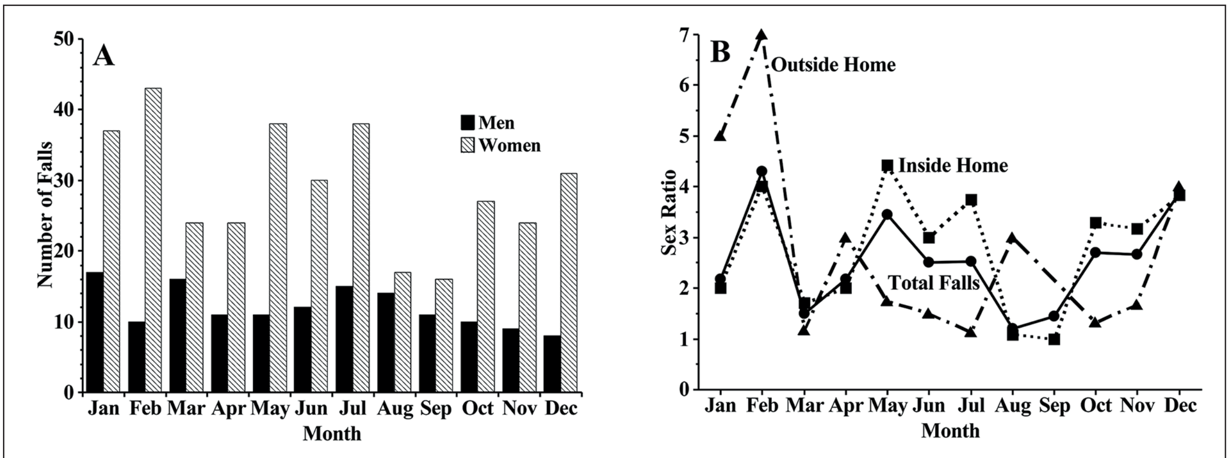

Figure 3. Month-of year pattern of serious falls of independently residing Spanish seniors. **A,** Number of falls per month separately of women and men. Neither women nor men exhibit evident sinusoidal-like annual patterning in falls. The total number of falls of women and men combined is higher during the summer months; although, they are greatest in number during the winter months of January and February. **B,** Sex (female/male) ratio (SR) of falls by month of year. SR of *outside-the-home* falls displays great month-to-month variability, being many-fold greater winter (January and February) and lowest summer (except August) and autumn. The temporal pattern in the SR of *inside-the home* falls is more random, being elevated during the winter month of February, late spring/summer months of May-July, and autumn/early winter months of October-December and lowest August and September.

hibit between-season variation, with winter peak and autumn trough (p = 0.01), but those of men do not (p > 0.50). The proportion of falls that are experienced outside the home by elderly men is greater during spring (35.3%) and summer (35.3%) than during winter (11.8%) and autumn (17.6%), but without statistical significance (p = 0.11). The proportion of such falls of elderly women shows less prominent seasonal differences and is also without statistical significance (p > 0.50), being highest during spring (28.2%) and winter (28.2%), lowest during autumn (19.7%), and intermediate during summer (23.9%).

Figure 3B additionally depicts the month-of-year data in terms of the female/male SR. No clear annual pattern is apparent in the SR of inside and outside-the-home fallers combined. The SR of inside-the-home fallers is elevated in February, May through July, and October through December. In contrast, the high-amplitude annual waveform of the SR of outside-the-home fallers is closely sinusoidal, with highest SR equal to ~7 for the month of February compared to ~2 or less for the months of May through July. Cosinor Analysis reveals near statistical significance for the annual pattern in the SR of outside-the-home fallers (p = 0.088); no annual pattern is found for the SR of inside-the-home fallers or inside and outside-the-home fallers combined (p > 0.40).

Discussion

Our investigation explored 24-h, 7-d, and 1-y patterns of community falls of independently living elderly (age ≥65 y) residents of a southern city in Spain according to intrinsic, i.e., age, sex, and medical conditions, and extrinsic, i.e., location, mode, and circumstances, factors. The data for this investigation were derived from the Accidents and Emergency Unit Services of a regional tertiary-level hospital in Cordova, Spain for year 2013. A total of 888 elderly falls were recorded. However, only 493 of them met all inclusion criteria to qualify for analysis, i.e., involved seniors who resided independently in a non-institutional setting, had medical assessment and treatment the same day as fall occurrence, was not a repeat fall episode by the same person during the study period, and the medical record listed as a minimum the variables of age and sex. Of these 493 medical records, 412 (83.6%) met the major inclusion criteria, that is, specification of clock hour of occurrence. Based on the findings of previous published investigations, we hypothesized that falls by seniors would be most frequent during the morning, weekend, and winter.

Cosinor Analysis substantiated prominent 24-h patterns with midday to late-afternoon peak time in serious falls by men and women of the three considered age categories of 65-74, 75-84, and 85^+ years that happen inside (p < 0.001) as well as outside (p = 0.011) the home while standing, walking, or moving on-stairs (p < 0.001) or ascending from or descending to furniture (p=0.004), and caused by an accident of unspecified nature (p<0.001) or collectively by fragility, syncope, and stroke (p = 0.005). The combined cause category of slip, stumble, and trip is of near statistical significance (p = 0.056). Most of the verified day/night patterns of falls are of high amplitude (amplitude ≥35% of the 24-h time series mean), and the Cosinor Analysis-derived peak time, no matter the age or sex of faller or associated cause, location, or mode (body position/activity) of incidents, is invariably between midday and early afternoon. Overall, the prominent peak time of senior falls is primarily representative of inside-the-home accidents by women ≥75 years of age that occurred while walking, standing, or moving on stairs. A far less prominent evening excess of falls is additionally identified and also involves falls more often of women than men that happen inside the home, frequently caused by faller fragility, syncope, or stroke and to lesser extent slip, stumble, or trip.

McMahon et al[42] reported that the 30-day risk for death, as an outcome measure of fall trauma severity, is significantly greater for those who present to the Emergency Medicine Department between 00:00-08:00 h than 08:00-16:00 h. Some 7.0% of the seniors of our investigation died from complications of their fall; however, without significant time-of-day differences (p = 0.23); in fact, in the present study fall mortality between 00:00-08:00 h (6 fatalities) is much lower, approximately half that, between 08:00-16:00 h (12 fatalities) or 16:00-00:00 h (11 fatalities).

The literature[45-47] suggests senior falls may be common overnight in association with frequent toileting due to high prevalence of nocturia in the aged. We thus anticipated there would be an excess of incidents nocturnally or in the morning when nighttime fallers would likely be discovered by caretakers or others. However, only 2.2% (N = 11) of falls in this study were specifically associated with bathroom activities, and they happened *in equal* number 00:00-08:00 h (N = 2) and 08:00-16:00 h (N = 2) and in slightly higher number 16:00-00:00 h (N = 5). We also expected a large number of falls would occur during the initial hours of the diurnal activity span based on reports[48-52] because seniors are more prone at this time of the day to antihypertension-medication (entailing ~65% of all the fallers) or neurogenic-caused dizziness and syncope. Moreover, ~30% of the fallers were taking medications to manage diabetes, i.e., regulate blood glucose level. Generally, these medications are ingested in the morning or with meals. An adverse effect of these medications is hypoglycemia, which can result in altered consciousness, cognition, and dizziness/syncope[50]. Cosinor Analysis of time series data specific to syncope as cause of fall (N = 54) reveals near statistical significance of 24-h patterning ($p = 0.056$); however, manifestation of the highest number of such incidents in this study is not in the morning as expected based on literature reports but afternoon at ~16:00 h.

We further explored if the type of prescribed and over-the-counter medications taken by seniors is linked with specific time-of-day fall patterns. Medications were grouped into three categories according to their potential to adversely affect vigilance, balance, and cognition and thus increase fall risk. Medications of such potential elevated impact are hypnotics, sedatives, antidepressants, and anxiolytics. Those of moderate to high impact are blood pressure and blood glucose regulators. Those of low impact are anticoagulants, aspirin, plus vitamins and other non-prescription supplements. The 24-h pattern of falls is essentially identical across the three medication categories. Each is characterized by a major midday to early afternoon peak and second lessor or comparably prominent peak at ~22:00 h. These findings suggest the 24-h pattern of elderly falls is uninfluenced by medications, even those considered to increase the risk for falls.

We expected the highest proportion of falls by elderly women to take place inside the home and the highest proportion of falls by elderly men to take place outside the home. This was not the case, most falls of both men (76.4%) and women (~79.7%) happened inside the home. The midday/afternoon siesta is a Spanish cultural tradition that is especially popular with seniors. The finding of the early afternoon peak incidence of falls by Spanish elderly suggests possible relationship with the siesta[46-47,53-55]. On the other hand, the excess of incidents at this time of day may be associated with activities linked with preparation of the early afternoon-timed midday meal in Spain, consequent postprandial hypotension and lethargy following its consumption[48,55], and/or midday sleepiness and associated dip in cognition[56].

Day-of-week disparity in total number of falls is detected in the 493 fallers for whom the time of the incident is accurately known. The overall peak incidence of falls weekdays is Wednesday and weekend days Saturday. In our sample, the overall female/male SR of fallers is ~2.4. However, the SR shows substantial day-of-week disparity. It is approximately this value or lower most days, but very much greater (~7) on Thursday. Additionally, ~4.5-fold more women than men experience falls inside their residence on Thursday, and ~3-fold more women than men experience them inside their residence on Saturday. Also, on average approximately twice as many women than men experience incidents outside their home Monday through Wednesday, while Friday through Sunday men and women experience them outside the home essentially in equal number. Cosinor Analysis substantiates day-of-week differences in outside-the-home falls by women ($p = 0.007$), with peak number on Thursday, but not inside-the-home ones ($p > 0.50$). Day-of week variation also is not found for number of falls by men that take place either inside or outside the home or for the two location categories combined (Cosinor Analysis: $p > 0.48$). We hypothesize that the substantially elevated Thursday SR of fallers that entails mainly inside-the-home incidents is representative of between-day differences by elderly women in their engagement in domestic tasks and activities of elevated risk. The lower than expected Saturday and Sunday SR of fallers perhaps relates to day-of-week differences between Spanish senior men and women of their involvement in scheduled outside-of- home community activities, like attendance of local fairs, food markets, and church services.

Overall, the total number of incidents of both elderly men and women in winter (December-February) is 1.5-fold higher than it is in autumn (September-November), and only slightly (1.18 to 1.16-fold) higher than it is in spring (March-May) and summer (June-August). Such seasonal variation is principally due to the 1.66-fold greater number of falls by women in winter than autumn. Senior men experience a much lower number of falls than women and show smaller seasonal variation, with 1.37-fold more falls in summer, when most numerous, than in autumn, when least numerous. The local climate of the city in which the study was conducted is continental Mediterranean. Environmental temperature is cool or cold in January (daily average temperature ~9.3°C) and warm to hot in July and August (daily average temperature 28°C, but with daytime temperatures often ≥40°C). Rain occurs primarily during the cooler months of October to April, i.e., autumn to spring. It is tempting to conclude the winter-time higher number of falls is the consequence of unfavorable weather – cool/cold temperature and precipitation – that increases risk for outside-the-home incidents. However, independent of season, the majority of falls of both senior women (79.7%) and men (76.4%) happen inside the home. Furthermore, the greatest proportion of falls by season experienced by both men and women outside the home is not always during winter or autumn, as might be expected given the environmental conditions then of elevated fall risk. Indeed, the proportion of falls experienced by elderly men outside the home is substantially greater during spring (35.3%) and summer (35.3%) compared to autumn (17.6%) and especially winter (11.8%). However, the proportion of falls experienced by elderly women outside the home seems to be associated with seasonal variation in weather; it is lowest in fall (19.7%), highest both in spring (28.2%) and winter (28.2%), and intermediate in summer (23.9%). Interestingly, the female/male SR of out-of-home senior fallers displays great month-to-month and seasonal variability; the average SR is several-fold greater (more women than men fallers) in January and February than May through July.

There are several strengths of our investigation. One is every fall incident is validated by a medical record. Additionally, all fall incidents are verified by medical records to be representative of non-institutionalized independently residing seniors aged ≥65 y. Finally, the clock hour and calendar date of every fall is accurately known according to the inclusion/exclusion criteria through information of the time of dispatch of emergency ambulance service, intake into the hospital emergency department, family member or other responsible individual, rather than patient recall, alone, which in the elderly may be unreliable. Data of the same year as the fall incidents reveal the average response time of the local ambulance service to an emergency call for service is ~9.5 min, suggesting ambulance response time per se is unlikely to significantly bias the clock-hour categorization of falls.

There are also several limitations of our investigation. One is some proportion of falls that happened overnight may have not been discovered until the following morning. In such cases, the recorded clock time of the fall incidents would differ markedly from the actual ones, and a morning-time excess of incidents might be expected. This is not observed. An additional limitation of our investigation is our findings are restricted to temporal patterns of senior falls of sufficient severity as to have motivated immediate clinical assessment and treatment by personnel of the AEUS and/or hospitalization. Indeed, the average (±SE) duration of hospitalization of the fallers is 8.6 (±6.0) d, without difference between women and men ($p = 0.45$). In this regard, some 7.0% of the elderly fallers transported to the AEUS and thereafter hospitalized for treatment died from fall-caused trauma within 30 d, with approximately one of three fallers hospitalized for ≤1 day dying, presumably due to high fall severity and/or high patient fragility. Falls of less severity that did not mandate immediate clinical assessment and those of much greater severity that resulted in immediate death were not transferred to the AUES and thus lost to analysis. Another limitation of the investigation is our findings are restricted to data obtained during a single year (2013) and single tertiary regional hospital of southern Spain, and as a consequence entails a relatively small sample size. Moreover, some senior fallers might have been transferred to other city hospitals and their data lost for analysis. Another important limitation is information on the primary inclusive criterion, i.e., residential status, was not listed in a large number (N = 310) of the medical records. We, therefore, conducted a separate analysis of the 247 medical records that did not list residential status of the faller but did list the time of day of the fall occurrence. Analysis of this dataset reveals identical 24-h patterning of incidents of this subset of senior men and women of unknown type of residence and with the same major midday/early afternoon prominent and minor late evening peaks and overnight trough as those of the known non-institutionalized independently residing elderly individuals (Figure 1). We found the precise listing of the clock hour of fall occurrence was absent in 81 medical records of independently residing seniors. It is unknown to what extent, if any, the findings regarding the 24-h pattern of falls as depicted in Figure

1 would have been different if the clock time of these 81 fallers had been recorded to enable their inclusion into our analyses. Additionally, while data pertaining to the intrinsic factors of age and sex of the faller and extrinsic factors of the cause and location of the fall incident were listed in all medical records, ~30% of the records did not chronicle mode. Thus, the findings specific for this extrinsic factor may not be representative. Finally, the findings of this investigation pertain to a Mediterranean sample of independently residing Spanish seniors likely adhering to a unique social routine characterized by late nocturnal bedtimes and late diurnal wake-up times, unusual distribution of daily, especially late lunch and supper, meals, plus midday/afternoon siesta. Thus, care must be taken in extending the findings of this report to other populations of different ethnicities, socio-cultural traditions, and activity patterns. This is true also for the day-of-week and month-of-year patterning of falls that may be specific, respectively, to the unique temporal patterns of activities of the local culture and customs plus seasonal patterns in weather conditions, indoor and outdoor family activities, and religious holidays and traditions.

Conclusions

Falls of community-dwelling independent seniors constitute major health, social, and economic problems. Time of fall occurrence is an important epidemiology variable and when analyzed by appropriate time series methods enables more comprehensive elucidation of associated and precipitating intrinsic and extrinsic factors. Knowledge of prominent 24-h, 7-d, and seasonal patterns of such incidents by community-dwelling independent elderly not only increases the understanding of their epidemiology but also provides additional insight to inform and improve fall prevention programs.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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References

1) Gillespie LD, Robertson MC, Gillespie WJ, Sherrington C, Gates S, Clemson LM, Lamb SE. Interventions for preventing falls in older people living in the community. Cochrane Dtabase Syst Rev 2012; 9: CD007146.
2) Spoelstra SL, Given BA, Given CW. Falls prevention in hospitals: an integrative review. Clin Nurs Res 2012; 21: 92-112.
3) Stalenhoef PA, Crebolder HFJM, Knottnerus JA, Van Der Horst FGEM. Incidence, risk factors and consequences of falls among elderly subjects living in the community: A criteria-based analysis. Eur J Public Health 1997; 7: 328-334.
4) Soriano TA, Decherrie L, Thomas DC. Falls in the community-dwelling older adult: A review for primary-care providers. Clin Interv Aging 2007; 2: 545-553.
5) Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing 2016; 35 Suppl 2: ii37-ii41.
6) Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988; 319: 1701-1707.
7) Yates SM, Dunnagan TA. Evaluating the effectiveness of a home-based fall risk reduction program for rural community-dwelling older adults. J Gerontol A Biol Sci Med Sci 2001; 56: M226-M230.
8) Deandrea S, Bravi F, Turati F, Lucenteforte E, La Vecchia C, Negri E. Risk factors for falls in older people in nursing homes and hospitals. A systematic review and meta-analysis. Arch Gerontol Geriatr 2013; 56: 407-415.
9) Smolensky MH, Portaluppi F, Manfredini R, Hermida RC, Tiseo R, Sackett-Lundeen LL, Haus E. Diurnal and twenty-four-hour patterning of human diseases: Cardiac, vascular, and respiratory diseases, conditions and syndromes. Sleep Med Rev 2015; 21: 3-11.
10) Smolensky MH, Portaluppi F, Manfredini R, Hermida RC, Tiseo R, Sackett-Lundeen LL, Haus E. Diurnal and twenty-four-hour patterning of human diseases: Acute and chronic common and un-common medical conditions. Sleep Med Rev 2015; 21: 12-22.

11) Ayala DE, Ucieda R, Hermida RC. Chronotherapy with low-dose aspirin for prevention of complications in pregnancy. Chronobiol Int 2013; 30: 260-279.

12) Cutolo M. Glucocorticoids and chronotherapy in rheumatoid arthritis. RMD Open 2016; 2: e000203.

13) Dallaspezia S, Suzuki M, Benedetti F. Chronobiological therapy for mood disorders. Curr Psychiatry Rep 2015; 17: 95.

14) De Giorgi A, Mallozzi Menegatti A, Fabbian F, Portaluppi F, Manfredini R. Circadian rhythms and medical diseases: does it matter when drugs are taken? Eur J Intern Med 2013; 24: 698-706.

15) Dhillon S, Clarke M. Tasimelteon: first global approval. Drugs 2014; 74: 505-511.

16) Hermida RC, Ayala DE, Smolensky MH, Fernández JR, Mojón A, Portaluppi F. Sleep-time blood pressure: Unique sensitive prognostic marker of vascular risk and therapeutic target for prevention. Sleep Med Rev 2016; 33: 17-27.

17) Smolensky MH, Lemmer B, Reinberg AE. Chronobiology and chronotherapy of allergic rhinitis and bronchial asthma. Adv Drug Deliv Rev 2007; 59: 852-882.

18) Smolensky MH, Hermida RC, Ayala DE, Portaluppi F. Bedtime hypertension chronotherapy: concepts and patient outcomes. Curr Pharm Des 2015; 21: 773-790.

19) Smolensky MH, Hermida RC, Reinberg A, Sackett-Lundeen L, Portaluppi F. Circadian disruption: new clinical perspective of disease pathology and basis for chronotherapeutic intervention. Chronobiol Int 2015; 33: 1101-1119.

20) Aharonoff GB, Dennis MG, Elshinawy A, Zuckerman JD, Koval KJ. Circumstances of falls causing hip fractures in the elderly. Clin Orthop Relat Res 1998; 348: 10-14.

21) Allander E, Gullberg B, Johnell O, Kanis JA, Ranstam J, Elffors L. Falls and hip fracture. A reasonable basis for possibilities for prevention? Some preliminary data from the MEDOS study Mediterranean Osteoporosis Study. Scand J Rheumatol Suppl 1996; 103: 49-52; discussion 53.

22) Bird ML, Hill KD, Robertson IK, Ball MJ, Pittaway J, Williams AD. Serum [25(OH)D] status, ankle strength and activity show seasonal variation in older adults: relevance for winter falls in higher latitudes. Age Ageing 2013; 42: 181-185.

23) Cantwell K, Burgess S, Morgans A, Smith K, Livingston M, Dietze P. Temporal trends in falls cases seen by EMS in Melbourne: the effect of residence on time of day and day of week patterns. Injury 2016; 47: 266-271.

24) Cantwell K, Morgans A, Smith K, Livingston M, Dietze P. Differences in emergency ambulance demand between older adults living in residential aged care facilities and those living in the community in Melbourne, Australia. Australas J Ageing 2017; 36: 212-221.

25) Flinkkilä T, Sirniö K, Hippi M, Hartonen S, Ruuhela R, Ohtonen P, Hyvönen P, Leppilahti J. Epidemiology and seasonal variation of distal radius fractures in Oulu, Finland. Osteoporos Int 2011; 22: 2307-2312.

26) Frisina PG, Guellnitz R, Alverzo J. A time series analysis of falls and injury in the inpatient rehabilitation setting. Rehabil Nurs 2010; 35: 141-146, 166.

27) Giladi AM, Shauver MJ, Ho A, Zhong L, Kim HM, Chung KC. Variation in the incidence of distal radius fractures in the U.S. elderly as related to slippery weather conditions. Plast Reconstr Surg 2014; 133: 321-332.

28) Inderjeeth CA, Barrett T, Al-Lahham Y, Mulford J, Nicklason F, Reberger C. Seasonal variation, hip fracture and vitamin D levels in Southern Tasmania. N Z Med J 2002; 115: 183-185.

29) Jacobsen SJ, Goldberg J, Miles TP, Brody JA, Stiers W, Rimm AA. Seasonal variation in the incidence of hip fracture among white persons aged 65 years and older in the United States, 1984-1987. Am J Epid 1991; 133: 996-1004.

30) Lau EM, Gillespie BG, Valenti L, O'connell D. The seasonality of hip fracture and its relationship with weather conditions in New South Wales. Aust J Public Health 1995; 19: 76-80.

31) Crawford JR, Parker MJ. Seasonal variation of proximal femoral fractures in the United Kingdom. Injury 2003; 34: 223-225.

32) López-Soto PJ, Smolensky MH, Sackett-Lundeen LL, De Giorgi A, Rodríguez-Borrego MA, Manfredini R, Pelati C, Fabbian F. Temporal patterns of in-hospital falls of elderly patients. Nur Res 2016; 65: 435-445.

33) Magota C, Sawatari H, Ando SI, Nishizaka MK, Tanaka K, Horikoshi K, Hoashi I, Nobuko H, Ohkusa T, Chishaki A. Seasonal ambient changes influence inpatient falls. Age Ageing 2017; 46: 513-517.

34) Manfredini R, Volpato S, Gallerani M, Pelati C, Signani F, Sessa G, Cellini M, Nardini M, Martini M, Contato E, Saltari P. When hospital patients fall: preliminary data from Ferrara, Italy. J Am Geriatr Soc 2011; 59: 1144-1146.

35) Manfredini R, Fabbian F, Pala M, De Giorgi A, Menegatti AM, Boari B, Salmi R, Gallerani M. Time of occurrence of in-hospital falls: a systematic mini review. J Am Geriatr Soc 2012; 60: 1183-1184.

36) Niino N, Yasumura S, Haga H, Ueno H, Oshima M, Higuchi Y. Falls among the elderly living in a rural community--prevalence and circumstances of falls by season. Nihon Koshu Eisei Zasshi 1995; 42: 975-981.

37) Simpson PM, Bendall JC, Patterson J, Tiedemann A, Middleton PM, Close JCT. Epidemiology of ambulance responses to older people who have fallen in New South Wales, Australia. Australas J Ageing 2013; 32: 171-176.

38) Tenías JM, Estarlich M, Fuentes-Leonarte V, Iñiguez C, Ballester F. Short-term relationship between meteorological variables and hip fractures: An

analysis carried out in a health area of the Autonomous Region of Valencia, Spain (1996-2005). Bone 2009; 45: 794-798.

39) Thompson PW, Taylor J, Dawson A. The annual incidence and seasonal variation of fractures of the distal radius in men and women over 25 years in Dorset, UK. Injury 2004; 35: 462-466.

40) Vikman I, Nordlund A, Näslund A, Nyberg L. Incidence and seasonality of falls amongst old people receiving home help services in a municipality in northern Sweden. Int J Circumpolar Health 2011; 70: 195-204.

41) López-Soto PJ, Manfredini R, Smolensky MH, Rodríguez-Borrego MA. 24-hour pattern of falls in hospitalized and long-term care institutionalized elderly persons: a systematic review of the published literature. Chronobiol Int 2015; 32: 548-556.

42) McMahon CG, Kenny RA, Bennett K, Bouamra O, Lecky F. Diurnal variation in mortality in older nocturnal fallers. Age Ageing 2012; 41: 29-35.

43) Nelson W, Tong YL, Lee JK, Halberg F. Methods for cosinor-rhythmometry. Chronobiologia 1979; 6: 305-323.

44) Refinetti R, Cornélissen GC, Halberg F. Procedures for numerical analysis of circadian rhythms. Biol Rhythm Res 2007; 38: 275-325.

45) Asplund R. Nocturia in relation to sleep, health, and medical treatment in the elderly. BJU Int 2005; 96 Suppl 1: 15-21.

46) López-Soto PJ, García-Arcos A, Fabbian F, Manfredini R, Rodríguez-Borrego MA. Falls suffered by elderly people from the perspective of health care personnel: a qualitative study. Clin Nurs Res 2018; 27: 675-691.

47) Araújo MF, Caldevilla NN, Maciel C, Malheiro F, Rodríguez-Borrego MA, López-Soto PJ. Record of the circumstances of falls in community: perspective in the Iberian Peninsula. Rev Lat Am Enfermagem 2018; 28: e2977.

48) Goswami N, Blaber AP, Hinghofer-Szalkay H, Montani JP. Orthostatic intolerance in older persons: etiology and countermeasures. Front Physiol 2017; 8: 803.

49) Lewis NC, Ainslie PN, Atkinson G, Jones H, Grant EJ, Lucas SJ. The effect of time-of-day and sympathetic α1-blockade on orthostatic tolerance. Chronobiol Int 2012; 29: 882-890.

50) Liao D, Xu Y, Zou R, Wu L, Luo X, Li F, Lin P, Wang X, Xie Z, Wang C. The circadian rhythm of syncopal episodes in patients with neurally mediated syncope. Int J Cardiol 2016; 215: 186-192.

51) Mineda Y, Sumiyoshi M, Tokano T, Yasuda M, Nakazato K, Nakazato Y, Nakata Y, Yamaguchi H. Circadian variation of vasovagal syncope. J Cardiovasc Electrophysiol 2000; 11: 1078-1080.

52) Van Dijk N, Boer MC, De Santo T, Grovale N, Aerts AJ, Boersma L, Wieling W. Daily, weekly, monthly, and seasonal patterns in the occurrence of vasovagal syncope in an older population. Europace 2007; 9: 823-828.

53) Dhand R, Sohal H. Good sleep, bad sleep! The role of daytime naps in healthy adults. Curr Opin Pulm Med 2006; 12: 379-382.

54) Kaida K, Ogawa K, Nittono H, Hayashi M, Takahashi M, Hori T. Self-awakening, sleep inertia, and P3 amplitude in elderly people. Percept Mot Skills 2006; 102: 339-351.

55) Le Couteur DG, Fisher AA, Davis MW, Mclean AJ. Postprandial systolic blood pressure responses of older people in residential care: association with risk of falling. Gerontology 2003; 49: 260-264.

56) Monk Th. The post-lunch dip in performance. Clin Sports Med 2005; 24: e15-23, xi-xii.