

Timing of Activities and their Effects on Circadian Rhythm in the Elderly with Dementia: A Literature Review

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Received date: Oct 21, 2014, Accepted date: Oct 31, 2014, Published date: Nov 8, 2014

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Abstract

Study Background: Circadian rhythm disorders (CRDs) occur in over 60 percent of patients with dementia and are associated with increased morbidity and mortality and poor quality of life. Regulating the circadian system through the use of light and activity has been shown to alter core clock processes and suggests that activities delivered at strategic times may be an effective mechanism through which to entrain (or reset) disrupted circadian rhythms in persons with dementia. However, the nature and optimal timing of daily activities remains relatively unknown.

Methods: The object of this review is to examine the role of timed activities in regulating circadian activity in older adults living with dementia. A rapid review process was used to identify relevant research with the search terms circadian rhythm, timed activity, sleep, dementia, and other relevant combinations.

Results and Conclusions: Symptoms of CRD in older adults with dementia may be alleviated by participating in activities at their corresponding optimal time window. Future research needs to evaluate single and multiple activity interventions with emphasis on optimal timing to treat or mediate disrupted circadian patterns in older adults with dementia.

Keywords: Circadian; Dementia; Activity

Introduction

The time of day at which we decide to do daily activities and tasks can determine our likelihood of having better health and resiliency in response to the effects of aging, especially dementia [1]. Synchronizing daily activities with the proper brain state leads to efficiency, production, protective health benefits, and properly entrained circadian rhythms, which can lead to a predictable sleep-wake cycle [2]. Circadian rhythms refer to the cyclical changes and fluctuations of biological processes occurring over about a 24-hour period (1 day). These biological processes are entrainable and endogenous and are mainly driven by the brain's biological "clock" [3]. A human's intrinsic clock is slightly longer than 24 hours, but environmental cues—the solar-dark cycle being the most important and profound—impinge on the individual to entrain their circadian rhythm to a 24-hour period [4,5]. These environmental and external cues are referred to as zeitgebers [5]. There is a growing interest in forging a link between the effects of aging on circadian rhythms and the effects of aging on sleep [6-8]. Sleep provides neurological and physiological benefits that are crucial to promoting health and bodily function [9]. No other timed activity synchrony is more important to brain plasticity and resilience than the one between sleep and the sleep/wake cycle [10].

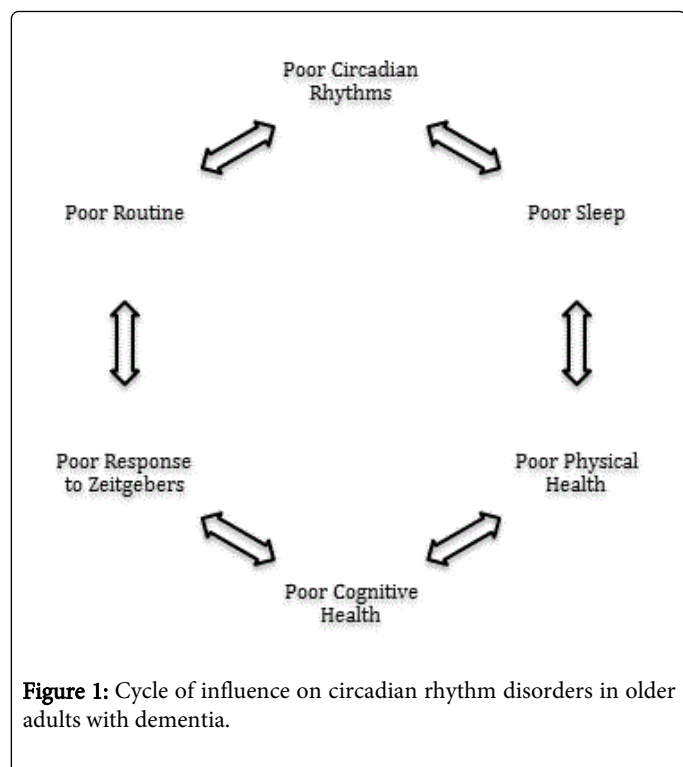
Circadian rhythm disorders (CRDs) occur in over 60 percent of patients with Alzheimer's disease and related dementias and are associated with increased morbidity and mortality and poor quality of life [10,11]. CRD symptoms include late afternoon/evening agitation (e.g., "sundowning") and irregular sleep-wake rhythms such as

daytime hypersomnia, frequent night awakenings, and poor sleep efficiency [12-14]. CRDs pose the greatest burden to family caregivers of persons with dementia, and are the principal causes of distress, poor quality of life (QoL), and institutionalization in this growing population [8,15].

CRD symptoms are at their peak during moderate stages of dementia due to the combined effects of poor physical and cognitive health on one's response to zeitgebers such as light (photic stimuli) and structured social and physical activity (nonphotic stimuli) that regulate, or entrain, the circadian clock. Figure 1 below depicts cyclical events that may lead to disrupted circadian rhythms in older adults with dementia.

Regulating the circadian system through the use of light and activity has been shown to alter core clock processes and suggests that activities delivered at strategic times may be an effective mechanism through which to entrain (or reset) disrupted circadian rhythms. However, the nature and optimal timing of these activities remains relatively unknown [16-18].

The purpose of this paper is to provide a systematic review of the research on the role of timed activities in regulating circadian activity in older adults living with dementia. Our intent is to evaluate both the nature or type of activities and the optimal timing of activities that align with the optimal daily circadian cycle. Of particular emphasis was to identify activities that could be useful in entraining disrupted circadian cycles in individuals with dementia. This review is the first to our knowledge to examine the key features and ideal scheduling of daily activities to reduce symptoms of CRDs.



PsycINFO (OVID), Scopus, and Cochrane Database, were searched to identify relevant studies published in the last 10 years, from January 2004 through October 2014. Search terms and their combinations included: condition (dementia, cognitive impairment, or cognitively impaired), activity (physical, cognitive, social), circadian (sundowning, sleep-wake rhythm), timing (timed, scheduled, routine) and older adult. Both authors assessed all titles and abstracts identified by the literature search for relevance.

Potentially relevant articles were then retrieved for full-text review. Each retrieved study was examined along the following criteria to determine eligibility for inclusion in this review: 1) published in a peer-reviewed journal and in English; 2) testing of an activity intervention; 3) inclusion of individuals over age 65 years with a physician diagnosis or caregiver report of any type of dementia; and 4) at least one outcome related to a factor affecting circadian rhythm (Figure 1). Using these criteria, the search yielded an initial set of 2,952 articles. The titles and abstracts were reviewed for relevance, which excluded 2,910 non-relevant studies. Articles were excluded if they had no activity component to the intervention, if the primary outcomes did not include factors related to circadian disruption in persons with dementia (Figure 1), if the activity interventions also included pharmacological treatment (melatonin), drug trials, or were conducted in lab or clinic setting. Forty two studies were retained for full review; this in turn yielded nine studies [20-28] that met full review criteria (Table 1).

Methods

A rapid review process was used to identify relevant articles [19]. Six electronic databases, MEDLINE (PubMed), CINAHL, Embase,

Author	Study Population	Intervention	Timing Addressed	Circadian Related Factors	Circadian related findings
Forbes et al. [20]	Aging population with dementia	Systematic Review of physical activity interventions	No	Cognitive function	Exercise interventions have promising effects on cognitive function
Andrade et al. [21]	Aging population with Alzheimer's	Multi-disciplinary exercise program	No	Physical & Cognitive function	The intervention group displayed increased frontal cognitive function, less body sway, and greater functional capacity
Yoon et al. [22]	Aging population with dementia	Cognitive and physical activity program	No	Cognitive function	A cognitive and physical activity program had significant beneficial effects compared to only a cognitive program
Vreugdenhil et al. [23]	Community dwelling patients diagnosed with Alzheimer's	Physical activity	No	Physical & Cognitive function	Physical activity improved physical and cognitive health compared to a control
Schmidt et al. [24]	Older morning chronotypes & young evening chronotypes	Cognitive activity	Yes	Physical & Cognitive function, Routine	Older individuals performed cognitive tasks better in the morning
Kemoun et al. [25]	Aging population with dementia	Physical activity	No	Physical & Cognitive function	The intervention group had improved cognitive test scores and improved walking efficiency
Christofoletti et al. [26]	Aging population with dementia	Multi-disciplinary exercise program	No	Physical & Cognitive function	Observed attenuation in decline of global cognition after multidisciplinary intervention compared to a single exercise

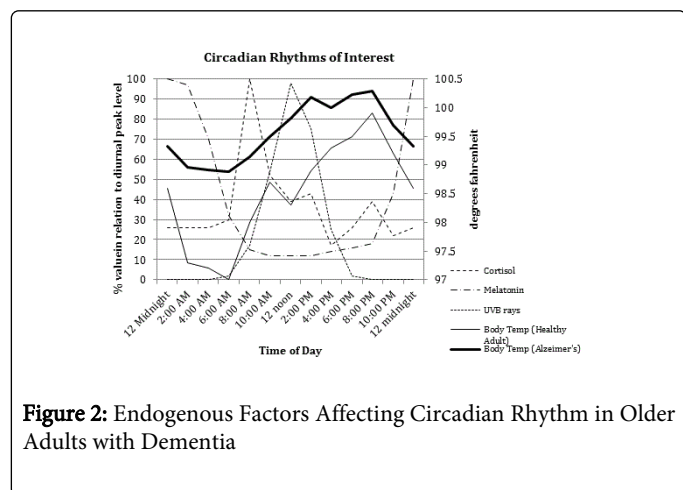
Kramer et al. [27]	Aging population, animal models	Systematic Review of physical activity interventions	No	Cognitive function	Physical activity moderated age related declines in cognition, brain function, and brain structure
Richards et al. [28]	Aging population with dementia living in nursing homes	Individualized Social Activity Intervention (ISAI)	Yes	Sleep & Routine	In individuals with sleep efficiency worse than 50%, ISAI group had less daytime sleep, a lower day/night sleep ratio, fell asleep faster, and were awake less at night

Table 1: Studies of Activity Influence on Circadian Related Factors in Persons with Dementia

Characteristics of Studies

Table 1 summarizes the essential components of the nine studies. Although there is no recognized classification system for activity based interventions, those reviewed here can be grouped into physical, social or cognitive activities. Two studies were reviews of physical activity interventions and seven studies tested cognitive, physical or social activity interventions (or combinations) in samples of older adults with dementia. While the studies discussed implications for reducing behavioral symptoms of circadian rhythm disorders, most studies included outcomes measures of physical and cognitive function as precursors to circadian disruption in this population. Two studies in the review included measures of sleep quality or sleep routine but no study in the review directly measured circadian rhythm (via actigraphy, behavioral or observational measures) as an outcome. Taken as a whole, there appears to be a very small body of evidence supporting the role of physical, cognitive and social activity in improving factors influencing circadian patterns. Only two of the studies discussed timing for delivery of activities in general terms (e.g., delivered between 9 am and 5 pm) [24,28].

Consideration of timing



Many factors may contribute to the optimal time window for cognitive, physical, and social activities. Exogenous factors such as light (UVB rays), and endogenous factors such as body temperature, cortisol, and melatonin are the largest drivers of circadian patterning [29]. As depicted in Figure 2, the circadian rhythms of hormones in the body adjust to sync with the dynamic light-dark cycles of the sun. For example, melatonin, the hormone involved in sleep onset, is inversely related to UVB rays suggesting sun fall induces sleep and sunrise induces waking.

In all humans, circadian rhythms are adapted to optimize the daily rhythm of environmental engagement [30]. Thus, engaging in activities at times when biological circadian processes are conducive to the specific activity can create optimal efficiency and output [31]. As aging occurs, circadian rhythms begin to become asynchronous. Studies have shown that enhancement of zeitgebers in elderly nursing home residents can have beneficial effects on their sleep [32]. By adopting a highly regular lifestyle, behavioral circadian rhythms become synchronous, and can accommodate for age-related declines in endogenous circadian entrainment mechanisms. In the following section we describe the optimal activities to complete at the specific time of day based on the factors depicted in Figure 2.

Morning (6 am to 10 am)

The sun is beginning to rise signaling humans to wake. Sensory recovery gradually happens as an individual wakes up and becomes alert. Body temperature progressively rises upon waking and plays a major role in alertness and function [33]. Blood levels of the hormone cortisol begin to increase as the sun begins to rise, and melatonin is sharply dropping. The majority of adulthood is spent waking between these hours.

As mid morning approaches, about two to three hours after wake, body temperature and cortisol create an optimum environment for cognitive based activities [34]. Elderly populations exhibit a phenomena where circadian rhythms of body temperature and motor activity are phase delayed [35], but their sleep/wake cycle is not delayed or delayed to the same degree. This phenomena creates extra time upon waking before optimal cognitive performance is reached compared to a healthy adult without CRD [22]. For persons with dementia, performing activities tailored to an individual based on their functional and mental status during the day are important in maintaining a consistent sleep-wake cycle and suggest that late morning is the optimal time for engaging in cognitive activities [22,36].

Afternoon (12 pm to 3pm)

Some mental alertness carries over after noon, but cortisol is sharply dropping causing a dip in performance of nearly any type during the afternoon hours. Improved reaction time, cognitive function, and energy levels are observed after short naps after a relatively short waking period [37]. In the elderly with dementia, naps can elicit negative results if too much time is spent sleeping or napping during the day [38].

Napping and sleeping during the day is an extremely common occurrence among older adults with dementia and has been attributed to a lack of structured routine and no meaningful engagement in activities. Ohayon and Zulley [38] exhibited a linearly increasing trend

of napping with age. Tanaka and colleagues [39] found that a combination of a structured 30-minute afternoon nap followed by moderate intensity exercise in the evening improved sleep quality, reduced subjective daytime sleepiness, and improved mental health.

Late Afternoon (3 pm to 6 pm)

Body temperature will reach its peak, which make blood flow, dexterity, grip strength, and limb control optimal during this time [40]. Other factors play a role in making this window ideal for physical activity. By this time, the brain is fatigued and cortisol levels are relatively low. Some sort of physical activity whereby the individual is actively engaged can help entrain circadian rhythms for later relaxation. Physical activity too late in the evening will delay melatonin onset and sleep onset. Therefore, performing an engaging physical activity in the late afternoon is optimal for healthy circadian rhythms. While the evidence supporting physical interventions aiding in sleep and circadian issues is promising and made up the majority of studies in the review [23,25,27], no study addressed optimal timing of physical activity for elderly populations with dementia.

Evening (6 pm to 10pm)

As the evening progresses, melatonin levels begin to rise quickly, cortisol levels drop, and the sun sets. This period should be for relaxing and winding down in preparation for sleep. Interventions to induce sleep for persons with dementia include the use of massage and touch to stimulate blood flow, reduce stress hormone production, induce relaxation, and can ease individuals into a calm relaxed state [41].

Sleep (~10 pm to ~6 am)

The synchrony of sleep timing with endogenous biological processes, solar-dark cycle, and conscious activities further promote healthy circadian patterning [6,9]. Morgenthaler et al (2006) graded the evidence regarding non-pharmacological treatments of sleep disturbance in older adults. The authors list stimulus control therapy, relaxation training, cognitive behavior therapy, sleep restriction therapy, multicomponent therapy, biofeedback, and paradoxical intention as, individually, effective therapies in the treatment of chronic insomnia. The evidence was lacking when it came to sleep hygiene education, imagery training, and cognitive therapy—as single therapies or when added to other approaches—being effective [42]. In addition, the review did not investigate having a steady “routine” of timed activities as a treatment, and individuals with dementia were excluded from the review. Nonetheless, based on the evidence presented in this review, having an organized daily routine—especially one that is in sync with the sun’s oscillation—in theory, should provide the basis for improving circadian patterns and therefore improved sleep. The reduced rate of insomnia in the elderly from maintenance of a daily routines study warrants further examination of timed activity protocols for aging populations, especially those with dementia [43].

Conclusion

Based on the collective literature examined in this literature review, when older adults with dementia engage in cognitive, physical, social, and relaxation activities at their optimal times, their circadian rhythms may have a higher likelihood of becoming properly entrained to environmental cues leading to improved sleep quality and reduced circadian rhythm disruption. Future research needs to be done to

determine the mechanisms underlying the optimal timing of activities, which activities are most effective, which combinations are effective, and how these activities actually aid in resetting circadian rhythm in those with dementia.

Acknowledgement

Dr. Hodgson has been supported in part by funds from the National Institute on Nursing Research (Grant P30 NR014131-01).

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