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Original Research Article

Sleep disturbances and their association with intrinsic capacity in older adults: insights from the longitudinal aging study in India

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ABSTRACT

Background: Intrinsic capacity (IC), encompassing cognition, locomotion, sensory function, vitality, and mood, is a key indicator of healthy aging. Sleep problems are common among older adults and may contribute to functional decline, but evidence from low- and middle-income countries is limited.
Methods: We analysed cross-sectional data from 27,395 community-dwelling adults aged ≥60 years from the longitudinal aging study in India (LASI). IC was assessed across five domains, and an IC score was generated on a scale of 0 to 10. Sleep problems were evaluated using self-reported difficulty falling asleep, nighttime awakenings, early morning awakenings, feeling unrested during the day, and daytime napping.
Results: The median age of participants was 67 years (IQR 63-72), and 51.7% were female. Regarding sleep, 19.8% reported trouble falling asleep, 23.2% experienced nighttime awakenings, 21.6% reported early morning awakenings, 20.5% felt unrested during the day, and 28.6% reported daytime napping. Older adults with difficulty initiating sleep, waking at night, waking too early, or feeling unrested during the day had significantly lower median IC scores compared with those without these problems (all $p<0.001$). Daytime napping was positively associated with IC ($\beta=0.123$, $p<0.001$).
Conclusions: Sleep disturbances are associated with reduced intrinsic capacity among older Indian adults, highlighting the importance of sleep assessment in geriatric care. Daytime napping may have a supportive role in maintaining functional capacity. Interventions targeting sleep could be a modifiable pathway to promoting healthy aging in this population.

Keywords: India, Intrinsic capacity, Older adults, Sleep disturbance

INTRODUCTION

Sleep is an essential contributor to the health and well-being of older adults. In India, it is estimated that the population of older adults will more than double from 100 million in 2011 to 230 million by 2036.[1] This means that nearly one in 7 people will be an older adult. Sleep physiology changes with age and can contribute to a range of chronic diseases and healthcare problems, making it an area of research interest.

Sleep disorders are fairly common in older adults in India. More than one-third of older adults either sleep for ≤5 hours or ≥10 hours per night, and nearly half report difficulties initiating or maintaining sleep, as well as experiencing daytime sleepiness.[2,3] Both short and long sleep durations, along with poor sleep quality, have been associated with multiple cardiometabolic disorders, including obesity, diabetes mellitus, hypertension, stroke, and coronary artery disease.[4] In addition, inadequate or disturbed sleep is linked to immune and endocrine

dysregulation, and a higher likelihood of falls, functional disability, depressive symptoms, and cognitive issues such as memory decline, cognitive impairment, and dementia.[5-12]

The World Health Organization (WHO) defines healthy aging as the ongoing process of developing and maintaining the functional ability that enables well-being in later life. Emphasizing this framework, WHO highlights intrinsic capacity (IC) as a key determinant of healthy aging.[13] IC, described by WHO as a composite measure encompassing an individual's physical and mental capacities, is operationally assessed across five domains: locomotion, cognition, psychological well-being, vitality, and sensory function (WHO, 2019).[14] IC provides a comprehensive framework to assess the healthcare needs of older adults.

Given the importance of sleep for healthy ageing in older adults, it is imperative that we understand its impact on the various domains of IC. Few large population studies have specifically examined the independent association of total sleep duration, daytime napping, and sleep disturbances with IC changes. However, the individual relationships between sleep duration, specific sleep patterns, daytime napping, and other domains of sleep with IC remain unclear and warrant investigation.[15] This study hypothesized that balanced/healthy sleep patterns can preserve intrinsic capacity and contribute to healthy ageing. Our objective was to examine the relationship between various sleep patterns and the IC domains. This, in turn, we believe, can help identify sleep behaviors and patterns that are detrimental to health and modify them.

METHODS

LASI sampling and design

LASI (longitudinal ageing study in India) employed a multistage, stratified sampling approach based on the 2011 census to achieve both national and state-level representativeness. In this framework, districts and tehsils served as the primary sampling units, while rural villages and urban wards served as the secondary sampling units. A comprehensive account of the sampling design, survey weights, and methodology has been detailed in earlier publications.[16] For the current analysis, we utilized data from 27,395 community-dwelling individuals aged 60 years and above. Informed consent was obtained from all participants after they were provided with an information sheet outlining the purpose of the study, confidentiality measures, and health assessment protocols. The first wave of LASI received ethical clearance from the Indian Council of Medical Research (ICMR) and was conducted in accordance with the Declaration of Helsinki.

Intrinsic capacity measurement

IC was evaluated across five core domains: cognition, locomotion, sensory function, vitality, and mood. The cognitive domain comprised several components, including immediate memory and delayed recall (memory), time and place orientation, backward counting and arithmetic tasks (numerical ability), paper folding and pentagon drawing (executive function), and object naming. A composite cognitive score was calculated by summing these components. To control for variations due to educational attainment, participants were categorized into three groups: those with no formal education, those educated through middle school, and those with secondary education or higher. Within each education group, cognitive scores were divided into tertiles, and individuals were assigned a score of 0 (lowest tertile), 1 (middle), or 2 (highest), allowing for an education-adjusted cognitive capacity score.

Sensory function was assessed through self-reported difficulties in vision and hearing. A score of 2 was given to those reporting no difficulty in either sense, 1 to those with impairment in one domain, and 0 to those with both visual and hearing difficulties. Locomotor capacity was measured using the semi-tandem balance test. Participants who could maintain balance for 10 seconds received a score of 2; those maintaining it for between 3.0 and 9.9 seconds received a score of 1; and those unable to hold the position for at least 3 seconds were given a score of 0.

Vitality was determined using body mass index (BMI). Individuals with a BMI of ≤18.4 kg/m^2 (underweight) were scored 0, those with a BMI of 18.5-24.9 kg/m^2 (normal weight) scored 1, and those with a BMI≥25.0 kg/m^2 (overweight or obese) scored 2. Mood was assessed using two self-reported questions: whether the individual had felt depressed or sad for two consecutive weeks, and whether they had lost interest in usual activities. A score of 0 was assigned to participants who responded "yes" to both questions, 1 to "yes" to either question, and 2 to "no" to both questions. Each domain contributed a score of 0-2, yielding a total intrinsic capacity score of 0-10. Higher scores indicated better overall intrinsic capacity.

Sleep problems

The LASI participants were asked about their sleep using questions such as "How often do you have trouble falling asleep?", "How often did you wake up during the night and had trouble getting back to sleep?", "How often did you wake up too early in the morning and were not being able to fall asleep again?", "How often did you feel unrested during the day, no matter how many hours of sleep you had?", and "How often did you take a nap during the day?". The reply to these questions were recorded as "never", "rarely (1-2 nights/week)", "occasionally (3-4 nights/week)" and "frequently (5 or more nights/week)". We further reduced the score into two categories: No sleep problem (response never and rarely) and with sleep problem (response occasionally and frequently). For the question regarding nap during the day

was also categorized as no (never and rarely) and yes (occasionally and frequently).

Covariates

The analysis included several covariates: age, sex (categorized as male or female), place of residence (urban or rural), and living arrangements. Living arrangements were classified into four categories: residing with both spouse and children, with either spouse or children, with other individuals, or living alone. Socioeconomic status was evaluated using quintiles of monthly per capita expenditure (MPCE). Education was grouped into four levels: no formal schooling, primary to middle school (grades I-VIII), higher secondary or diploma, and graduate or postgraduate qualifications.

Substance use was assessed based on current tobacco and alcohol consumption. The presence of chronic health conditions was determined through self-reported physician diagnoses, including diabetes, hypertension, cardiovascular disease, stroke, hyperlipidemia, musculoskeletal disorders, and chronic respiratory diseases. Multimorbidity was defined as having two or more of these chronic conditions.

Statistical analysis

All statistical analyses were performed using Stata version 17.0 (StataCorp. Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC; 2021), while visualizations were created using GraphPad Prism version 8 (GraphPad Software, San Diego, CA). Descriptive analyses were carried out to summarize the characteristics of the study population. Categorical variables were expressed as counts and percentages. For continuous variables, the distribution was evaluated using the Shapiro-Wilk test. Depending on the normality of the data, results were presented as mean with standard deviation (SD) or median with interquartile range (IQR).

To assess differences in IC scores between individuals with and without sleep problems, either the independent t-test or the Wilcoxon rank-sum test was used, depending on the data distribution. To further evaluate the strength of association, linear regression analyses were conducted. Four models were constructed: model 1 was unadjusted; model 2 was adjusted for age and sex; model 3 was adjusted for age, sex, and comorbidities; and model 4 included all sleep-related variables and was adjusted for the covariates in model 3. Results were reported as β-coefficients with 95% confidence intervals (CI). A p value of less than 0.05 was considered statistically significant.

RESULTS

In the final analysis, 27,395 community-dwelling older adults were included. The median age (IQR) was 67 years (63-72), 14,166 (51.7%) were female, and 18,295 (66.8%) were from rural areas. The majority (90%) lived with a spouse or children, and 14,605 (53.3%) had no formal education. Among comorbidities, hypertension (9,412; 34.4%) was the most common, followed by diabetes (4,145; 15.1%) and heart disease (1,358; 4.9%). Other baseline characteristics are reported in Table 1.

Table 1: Baseline characteristics of included participants (n=27,395).

Variables	Frequency	Percentage
Age [Median (IQR)]	67 (63-72)	
Sex		
Male	13229	48.29
Female	14166	51.71
Residence		
Rural	18295	66.78
Urban	9100	33.22
Living arrangement		
Living with spouse and children	12031	43.925
Living with spouse or children	12570	45.88
Living with others	1367	4.99
Living alone	1427	5.21
MPCE		
Poorest	5599	20.44
Poorer	5673	20.71
Middle	5648	20.62
Richer	5406	19.73
Richest	5069	18.50
Education		
No formal education	14605	53.31

Continued.

Variables	Frequency	Percentage
Up to IX standard	8698	31.75
X and above	4092	14.94
Marital Status		
Married	17759	64.83
Widowed	9087	33.17
Divorced	312	1.14
Never married	237	0.87
Tobacco use	10843	39.59
Alcohol use	4767	17.40
Self-rated health		
Poor	3565	13.02
Fair	8982	32.79
Good	10053	36.70
Very good	4017	14.66
Excellent	775	2.83
Comorbidities		
Hypertension	9412	34.36
Diabetes	4145	15.13
Heart disease	1358	4.96
Stroke	584	2.13
High cholesterol	1023	3.73
Bone and joint disease	4811	17.56
Chronic lung disease	2051	7.49
Multimorbidity	6318	23.06
Intrinsic capacity		
Cognition		
Good	10247	37.40
Fair	10161	37.10
Poor	6987	25.50
Sensory		
Both intact	1930	7.04
One impaired	13905	50.76
Both impaired	11560	42.20
Locomotor		
Good	9388	34.26
Fair	9039	33.00
Poor	8968	32.74
Vitality		
Good	6632	24.21
Fair	14390	52.53
Poor	6373	23.26
Mood		
Good	22062	80.53
Fair	2789	10.18
Poor	2544	9.29
Sleep disturbance		
Trouble falling asleep	5422	19.79
Wake up during the night and trouble getting back to sleep	6349	23.18
Wake up too early	5932	21.65
Unrested during the day	5618	20.51
Nap during the day	7827	28.57

Intrinsic capacity and sleep problems

Across various domains of IC, cognition was good in 10,247 (37.4%), both the sensory (vision and hearing) were intact in 1,930 (7.0%), locomotor capacity, vitality, and mood were good in 9,388 (34.3%), 6,632 (24.2%), and 22,062 (80.5%), respectively. Among the 27,395 participants, 5,422 (19.8%) reported trouble falling asleep, 6,349 (23.2%) had a history of waking up during the night and trouble getting back to sleep, 5,932 (20.5%) felt unrested during the day, and 7,827 (28.6%) reported taking a nap during the day.

Association between IC score and sleep problems

We observed that, older adults who had trouble falling asleep [5 (4-7) versus 6 (4-7), p value <0.001], who would wake up during the night [5 (4-7) versus 6 (4-7), p<0.001], who wake up too early [5 (4-7) versus 6 (4-7)] and those who felt unrested during the day [5 (4-6) versus 6 (4-7)] had a statistically significantly lower IC score than those without these sleep problem (Table 2). The IC score between those who took a nap during the day and those who did not [6 (4-7) versus 6 (4-7), p=0.849] was comparable.

Table 2: Association between sleep and total IC score.

	IC score Mean (SD)	IC score Median (IQR)	P value
Trouble falling asleep			
Yes	5.21 (1.80)	5 (4-7)	<0.001
No	5.57 (1.69)	6 (4-7)	
Wake up during the night and trouble getting back to sleep			
Yes	5.23 (1.78)	5 (4-7)	<0.001
No	5.58 (1.70)	6 (4-7)	
Wake up too early			
Yes	5.22 (1.79)	5 (4-7)	<0.001
No	5.58 (1.69)	6 (4-7)	
Unrested during the day			
Yes	5.21 (1.77)	5 (4-6)	<0.001
No	5.58 (1.71)	6 (4-7)	
Nap during the day			
Yes	5.51 (1.77)	6 (4-7)	0.849
No	5.50 (1.71)	6 (4-7)	

Table 3: Results of linear regression analysis.

Sleep	Model 1*		Model 2**	
	β-Coefficient (95% CI)	P value	β-Coefficient (95% CI)	P value
Trouble falling asleep	-0.360 (-0.412 to -0.309)	<0.001	-0.293 (-0.343 to -0.244)	<0.001
Wake up during the night and trouble getting back to sleep	-0.348 (-0.397 to -0.300)	<0.001	-0.292 (-0.339 to -0.246)	<0.001
Wake up too early	-0.358 (-0.408 to -0.309)	<0.001	-0.302 (-0.350 to -0.255)	<0.001
Unrested during the day	-0.363 (-0.413 to -0.312)	<0.001	-0.314 (-0.363 to -0.265)	<0.001
Nap during the day	0.004 (-0.041 to 0.049)	0.849	0.066 (0.023 to 0.110)	0.003

Model 1: unadjusted, Model 2: adjusted for age and sex.

Table 4: Results of complex linear regression analysis adjusted for age sex and comorbidities.

Sleep	Model 3*		Model 4**	
	β-Coefficient (95% CI)	P value	β-Coefficient (95% CI)	P value
Trouble falling asleep	-0.344 (-0.393 to -0.294)	<0.001	-0.145 (-0.206 to -0.085)	<0.001
Wake up during the night and trouble getting back to sleep	-0.335 (-0.382 to -0.289)	<0.001	-0.129 (-0.189 to -0.070)	<0.001
Wake up too early	-0.334 (-0.381 to -0.287)	<0.001	-0.125 (-0.186 to -0.065)	<0.001
Unrested during the day	-0.350 (-0.398 to -0.302)	<0.001	-0.217 (-0.274 to -0.161)	<0.001
Nap during the day	0.017 (-0.026 to 0.059)	0.449	0.123 (0.079 to 0.167)	<0.001

Model 3: adjusted for age, sex and comorbidities (hypertension, diabetes, heart disease, stroke, high cholesterol, bone and joint disease, lung disease). Model 4: All sleep variable included and adjusted for variables same as Model 3.

The results of linear regression (model 1 and model 2) are reported in Table 3, while model 3 and model 4 results are reported in Table 4. Model 1 was unadjusted, model 2 was adjusted for age and sex, model 3 was adjusted for age, sex, and comorbidities, while model 4 includes all sleep variables and was adjusted for age, sex, and comorbidities. In the unadjusted model, we found that all sleep problems, except nap during the day, were associated with lower IC scores.

In the fully adjusted model (model 4), we found that trouble falling asleep (β=-0.145, p<0.001), waking up at night (β=-0.129, p<0.001), waking up too early (β=-0.125, p<0.001), feeling unrested during the day (β=-0.217, p<0.001) were associated with lower IC score, while taking nap during the day (β=0.123, p<0.001) was associated with higher IC score (Figure 1).

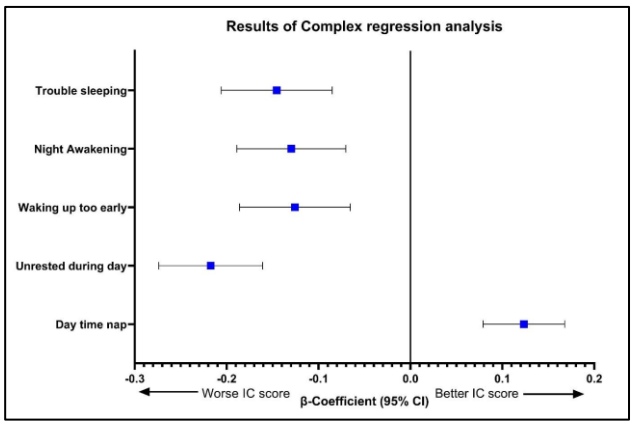

Figure 1: Forest plot showing the results of complex linear regression analysis.

DISCUSSION

This study, based on LASI data, examines the association between sleep disturbances and the various domains of IC. In our analysis of 27,395 older adults, we found that the majority had impairments in vision, hearing, locomotion, vitality, and cognition. The most common sleep-related problems reported were feeling unrested during the day, waking up in the night, and having trouble falling asleep again. In the fully adjusted model, having trouble falling asleep, waking up too early, and feeling unrested during the day were associated with lower IC scores, whereas daytime naps were associated with higher IC scores. This study highlights the association of impaired quality, duration sleep with a decline in intrinsic capacity.

Across the various domains of IC, cognition was good in 37.4% of the participants, both sensory (vision and hearing) were intact in 7.0% (highest decline), locomotor capacity, vitality, and mood were good in 34.3%, 24.2%, and 80.5%, respectively. In a study conducted in community dwelling older adults in India, it was found that most prevalent impaired domain was locomotor (59.3%), followed by vision (44.1%), hearing (19.3%), cognition (10.6%), mood (3.8%), and vitality (3.7%), similar to the outcomes in our study.[16] In a cross-sectional study of older adults in China, similar patterns of decline in IC were evident. At least 39% older adults showed a decline in one domain, with 52.4% showing a decline in the sensory domain. Furthermore, sensory, locomotion, and cognition were the most common 3 domains affected in the population.[17]

Of the 27,395 participants, 19.8% reported trouble falling asleep, 23.2% had a history of waking up during the night and trouble getting back to sleep, 20.5% felt unrested during the day, and 28.6% reported taking a nap during the day. Similar outcomes were observed in another cross-sectional study in India: 12.36% of the population had a sleep latency of 31-60 min, 22.47% had a sleep duration of <5 hours, and 23.6% reported sleep disturbance more than thrice a week.[18] In a systematic review and meta-analysis of sleep patterns across different geographical regions, it was found that nearly half of the older adults had poor sleep quality and short sleep duration. Additionally, one in five individuals experienced excessive sleep, insomnia, and worsened sleep problems, more so in America during the COVID pandemic.[19]

In the fully adjusted analysis eliciting the association of IC to sleep problems, we found that trouble falling asleep (p<0.001), waking up at night (p<0.001), waking up too early (p<0.001), and feeling unrested during the day (p<0.001) were associated with a lower IC score. In a study based on the WHO Study on Global Aging and Adult Health in Mexico, it was found that those with poor self- reported sleep had greater odds of developing mild cognitive impairment and frailty (OR=1.68, 95% CI: 1.01-2.78), (OR=1.66, 95% CI: 1.13-2.46).[20] In a study of community-dwelling older adults in Japan, shorter sleep duration and poor sleep quality (as measured by a high PQSI score) were associated with exhaustion, whereas longer sleep duration was associated with lower physical activity.[21] In a cross-sectional study conducted on older adults (>60 years) in the city of Zagreb, it was found that both poor sleep duration and impaired quality of sleep could independently contribute to a decline in self- rated health (OR=3.21; 95% CI 1.61 to 6.39).[22]

In another study conducted among older adults at a tertiary care center in India, participants with cognitive impairment had shorter sleep duration and poorer overall sleep quality than those with good cognition (p<0.001).[23] In a study based on global aging and adult health (WHO-SAGE) in India poor sleep quality was found, associated with exhaustion (OR: 4.28; CI: 2.28-8.06), weak grip strength (OR: 2.31; CI: 1.46-3.67), and low physical activity (OR: 2.81; CI: 1.10-7.21).[24] The above studies suggest that poor sleep duration or quality may be associated with cognitive impairment, frailty, physical exhaustion, and poor self-rated health, thereby contributing to the decline in IC.

In a cross-sectional study conducted in Taiwan among healthy older adults, a one-point increase in sleep health was significantly associated with a 9% reduction in the odds of poor IC. An increase in daytime alertness was related to the greatest reduction in poor IC (OR, 0.64; 95% CI, 0.52-0.79). In addition, sleep regularity (OR, 0.77; 95% CI, 0.60-0.99), sleep timing (OR, 0.80; 95% CI, 0.65-0.99), and sleep duration (OR, 0.77; 95% CI, 0.61-0.96) were associated with reduced odds of poor IC 25. In the WHO-SAGE study, long sleep duration was associated with lower odds of exhaustion (OR: 0.86; CI: 0.73-1.00).[24] A similar outcome of improvement in IC scores while taking a nap during the day ($p<0.001$) was found in our study.

In a study on the validation of intrinsic capacity and healthy sleep pattern in middle-aged and older adults, based on CHARLS (China Health and Retirement Longitudinal Study) it was found that excessive (>10 hours) (total, ME: −1.12; 95% CI: −1.61, −0.64) and insufficient (<6 hours) sleep duration (total, ME: −0.43; 95% CI: −0.68, −0.18) negatively impacted IC change. Moderate naps (≤60 minutes) mitigated the decline in IC change (ME: 0.28; 95% CI: 0.07, 0.49) (ME-marginal effect).[15] Another study based on CHARLS suggested that the persistent short sleep at night without napping trajectory group (OR=1.64, 95% CI: 1.26-2.12) exhibited a significantly higher risk of low IC.[26]

In a cross-sectional study that utilized data from the FREVO (risk factors for aging) cohort, in Petrolina, Brazil, it was found that the, mean scores for the IC domains were 19.3±5.3 for cognition (MoCA), 9.9±1.8 for locomotion (SBBP), 12.1±1.8 for vitality (MNA), 5.4±2.7 for vision (Snellen), 5.3±2.5 for hearing (Wisper) and 3.0±2.5 for psychological state (GDS). The statistically significant models showed that sleep quality ($r=0.25$; $p<0.001$) and age ($r=0.25$; $p<0.001$) had a weak positive correlation with IC.[27] Thus, multiple studies conducted in Southeast Asia and globally could attest to the negative association of poor sleep quality/duration and decline in IC, while daytime naps were associated with a marginal improvement in IC, as reported in our study.

This study has several notable strengths. First, it uses data from the LASI, a nationally representative survey of community-dwelling older adults, enabling generalizability of the findings across diverse regions of India. The large sample size of over 27,395 individuals increases the analysis's statistical power. The use of a multistage, stratified sampling strategy based on the 2011 Census enhances the methodological rigor and representativeness of the dataset. IC was comprehensively assessed across all five WHO-recommended domains-cognition, locomotion, sensory, vitality, and mood. Importantly, cognitive scores were adjusted for educational attainment to reduce bias related to literacy differences. Sleep problems were evaluated using multiple symptom-based questions, and the study employed a stepwise regression modeling approach, progressively adjusting for demographic and clinical covariates, thereby providing a robust evaluation of the association between sleep disturbances and IC.

That said, the study has a few important limitations. Because the analysis is cross-sectional, it cannot tell us whether sleep problems lead to reduced intrinsic capacity or whether the reverse is true- the relationship could go either way. Information on sleep and chronic illnesses was based on self-reports, which might be prone to memory lapses or misreporting. Also, sleep was not assessed using standardized tools or objective methods such as actigraphy or sleep studies, which means the data may not fully capture the quality or severity of sleep issues. Although we adjusted for key factors such as age, sex, and comorbidities, it's possible that other relevant influences- like physical activity, pain, or medication use-could still be affecting the results. Finally, while we found that daytime napping was linked to better intrinsic capacity, this result should be interpreted with caution, as it may be influenced by cultural habits or by unmeasured factors such as overall frailty or nighttime sleep quality.

CONCLUSION

In this large, nationally representative study of older Indian adults, we found that several sleep problems-including difficulty falling asleep, waking during the night, waking too early, and feeling unrested during the day- were significantly associated with lower intrinsic capacity, even after adjusting for age, sex, and comorbidities. In contrast, daytime napping showed a modest positive association with intrinsic capacity. These findings underscore the importance of recognizing and addressing sleep disturbances in older adults as part of comprehensive geriatric care. Improving sleep health may represent a modifiable pathway to preserving or enhancing intrinsic capacity and promoting healthy aging in this population.

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