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Association between sleep health and intrinsic capacity among older adults in Taiwan

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ABSTRACT

Although the association between poor sleep quality and frailty has been previously reported, the relationship between sleep health and intrinsic capacity (IC) remains largely unknown. We aimed to examine the association between sleep health and IC among older adults. This was a cross-sectional study, and 1268 eligible participants completed a questionnaire collecting information on demographic, socioeconomic, lifestyle, sleep health, and IC. Sleep health was measured by the RU-SATED V2.0 scale. High, moderate, and low levels of IC were defined using the Integrated Care for Older People Screening Tool for Taiwanese. The ordinal logistic regression model estimated the odds ratio and corresponding 95% confidence interval. Low IC was significantly associated with age of 80 years or above, female, currently unmarried, uneducated, currently not working, financially dependent, and having emotional disorders. 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 (aOR, 0.64; 95% CI, 0.52–0.79). In addition, the subitems sleep regularity (aOR, 0.77; 95% CI, 0.60–0.99), sleep timing (aOR, 0.80; 95% CI, 0.65–0.99), and sleep duration (aOR, 0.77; 95% CI, 0.61–0.96) were associated with a reduced OR of poor IC but with marginal statistical significance. Our findings showed that sleep health across multiple dimensions is related to IC, particularly daytime alertness in older adults. We suggest developing interventions to improve sleep health and prevent IC decline, which is crucial in causing poor health outcomes.

1. Introduction

The prevalence of sleep disorders has surged in the past years [1]. Sleep-related problems affect around half of older adults aged over 60 years and results in various health conditions, such as fatigue [2,3], slow gait speed, and physical inactivity [4,5]. These conditions are known to increase the risk of frailty [6]. Even in healthy people, insufficient sleep, short sleep duration, and sleep disturbances may have a greater impact on well-being and quality

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of life [7]. Current attention was further paid to the importance of good sleep health, defined as holistic sleep characteristics, including subjective satisfaction, suitable timing, sufficient duration, high efficiency, and continuous alertness during waking time [8,9].

Intrinsic capacity (IC) is defined by World Health Organization (WHO) as *the composite of all the physical and mental capacities of an individual can draw on* [10]. The decline in IC among older people is usually associated with adverse health outcomes, such as falls and deterioration in activities of daily living and instrumental activities of daily living [11,12]. Loss IC composite score at admission was associated with an increased risk of 1-year mortality after discharge among older hospitalized patients [13]. Therefore, IC demonstrated a strong potential to predict negative health outcomes among older adults in different clinical settings [14] as well as in community-dwelling older people. In recent years, the Integrated Care for Older People (ICOPE) screening tool is suitable for identifying people exhibiting a decline in IC and may help provide person-centered interventions [14].

An appraisal of the association between sleep health and IC is expected to be helpful in setting strategies to increase the level of IC by improving sleep health among older adults. Although the association between poor sleep quality and frailty has been previously reported [15–17], sleep health is a multidimensional indicator that provides a more comprehensive understanding of sleep instead of solely focusing on individual subitems such as sleep quality. Moreover, frailty can be prevented through improving IC [18,19]. However, the association between IC and sleep health among older people remains underexplored. Additionally, IC and frailty might represent two sides of the same coin. IC represents the reserves and residual capacity of the individual, while frailty signifies the deficits accumulated with aging. In recent years, the WHO has sought to develop the concept of IC due to the stigma faced by individuals experiencing age-related disabilities related to frailty [20]. By measuring IC, we can track the trajectories of functioning and inform public health strategies aimed at promoting healthy aging. Therefore, in this study, we examined the association between sleep health and IC among older adults. We hypothesized that better sleep health would be related to a reduction in poor IC. We also tested the relationship between each dimension of sleep health and various levels of IC.

2. Methods

2.1. Study participants and data collection

This cross-sectional study was conducted from April to November 2022 among older adults in southern Taiwan. Older adults were recruited with convenient sampling from three sources: communities in Tainan City, outpatient clinics, and inpatient wards at National Cheng Kung University Hospital (NCKUH). Eligible participants met the following inclusion criteria: (i) age above 60 years; (ii) ability to communicate using Mandarin Chinese or Taiwanese; and (iii) ability to provide consent for participation. Well-trained interviewers conducted face-to-face interviews using a questionnaire to collect data. The procedures and arrangements of the study followed and adhered to the Declaration of Helsinki. All participants signed a written informed consent form for participation. The study was approved by the Institutional Review Board of NCKUH (IRB No.: A-ER-110-249).

2.2. Measurements

2.2.1. IC level

To evaluate the level of IC in this study, we used the key domains of the Integrated Care for Older People Screening Tool for Taiwanese (ICOPES-TW) screening tool, which is derived from the ICOPE guidelines with possible subdomains provided in a report of the WHO framework [10]. The ICOPES-TW included the following domains: (1) cognition domain including three items (time orientation, location orientation, memory); (2) locomotion domain including one item (mobility); (3) vitality domain including two items (weight loss over 3 kg, loss of appetite); (4) visual domain including one item (difficulty in watching); (5) hearing domain including one item (ability in repeating the number of 6, 1, and 9); and (6) psychological domain including two items (feeling bothersome, reducing engagements in activities). Each domain was dichotomously converted into 0 (no problem) or 1 (having the problem), and the IC score ranged from 0 to 6, with a higher score indicating poor IC [21]. We categorized the IC scores into three levels, with a score of 3 and above representing low IC, 1–2 indicating moderate IC, and 0 designating high IC. A higher ICOPES-TW score represents poorer IC.

2.2.2. Sleep health

Sleep health in the past month was measured using the RU-SATED V2.0 scale for Taiwanese. RU-SATED is a valid measure of sleep health among older adults with potentially useful clinical applications [8,22]. The measure consists of six items, each assesses one aspect of sleep health: sleep regularity, satisfaction, alertness, timing, efficiency, and duration. The items are each rated on a three-point Likert scale: rarely/never (0), sometimes (1), and always (2), with higher scores indicating better sleep health.

2.2.3. Lifestyle factors

We assessed five lifestyle factors in the past month: smoking, alcohol consumption, chewing betel quid, mild exercise, and vigorous exercise, as reported by the participants. An Indian study showed that tobacco use, alcohol consumption, and physical activity are strongly associated with IC among older adults [23]. Additionally, betel quid chewing is a predictor of health in older Taiwanese adults [24,25].

2.2.4. Emotional disorders

Information was collected by self-reporting of the participants. Sleep disorder and depression often coexist due to common causality [26]. The participants had to answer whether the physician diagnosed them with emotional disorders, such as depression, anxiety, or panic disorder. The variable was dichotomized into no or yes, and the later represents having emotional disorder history.

2.2.5. Socio-demographic and -economic characteristics

Several demographic data were collected: age (60–69, 70–79, 80+), sex (male and female), marital status (currently married, or others), living arrangement (alone or not alone), and religion (no religion, Buddhist, Taoism, others). Socioeconomic information included educational level (uneducated, primary, junior school, and senior high or above school), currently working (yes or no), and financial independence (yes or no).

2.3. Statistical analysis

We first compared the characteristics of older people with various levels of IC (i.e., high, moderate, or low) by using $\chi 2$ tests. The levels of IC were determined and met the proportional odds assumption. The Brant test showed that our dataset satisfied the proportional odds assumption ($p = 0.22$). Crude and covariate-adjusted odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) of various IC levels in relation to sleep health were estimated from the ordinal logistic regression model.

Statistical analyses were conducted using R programming language (version 4.2.3) with the MASS package. The level of significance was set to an alpha of 0.05.

3. Results

3.1. Participants

Of the 1268 participants with the completed questionnaire (repones rate 90%), low IC was significantly associated with age of 80 years or above, female, currently unmarried, uneducated, currently not working, and financially dependent, as shown in the demographic and socioeconomic characteristics in Table 1. Older people with low IC levels had a higher prevalence of recruitment from inpatient wards (Table 1). Table 2 compares the lifestyle, emotional disorder, and sleep health of study subjects in terms of their IC levels. The low IC group was less likely to engage in mild or vigorous exercise but more likely to have emotional disorders and lower scores on sleep health.

3.2. Correlations and regression analyses

Table 3 shows that a one-point increase in sleep health was significantly associated with a lower crude OR (0.83, 95% CI, 0.79–0.86) of poor IC. Sequential adjustment for socio-demographics, lifestyle, emotional disorder, and recruitment settings for covariates did not contribute much to the associations between better sleep health and lower IC. The OR was estimated at 0.91 (95% CI, 0.86–0.96) in the full-adjusted model. Overall sleep health was significantly associated with overall IC, and specific sleep subitems showed differential associations with IC. We found that a higher daytime alertness was associated with the most reduced covariate adjusted ORs (0.64, 95% CI, 0.52–0.79) of poor IC. Although higher scores of the subitems regularity (OR, 0.77, 95% CI, 0.60–0.99), timing (OR, 0.80, 95% CI, 0.65–0.99), and duration (OR, 0.77, 95% CI, 0.61–0.96) were each associated with reduced ORs of poor IC, the level of significance was only marginal (Table 4).

Table 1
Comparisons of socio-demographic characteristics and socioeconomic factors among older adults with various levels of intrinsic capacity (n = 1268).

	High IC[a]		Moderate IC[a]		Low IC[a]		p value
	n = 832, 65.6%		n = 373, 29.4%		n = 63, 5.0%		
	n	%	n	%	N	%	
Demographic characteristics							
Age (years)							
60–69	394	47.36	92	24.66	10	15.87	<0.001
70–79	364	43.75	172	46.11	16	25.40	
80+	74	8.89	109	29.22	37	58.73	
Gender							
Male	428	51.44	161	43.16	28	44.44	0.0231
Female	404	48.56	212	56.84	35	55.56	
Marital status							
Currently Married	619	74.40	250	67.02	39	61.90	0.0069
Others	213	25.60	123	32.98	24	38.10	
Live alone							
Yes	95	11.42	49	13.14	3	4.76	0.1526
No	737	88.58	324	86.86	60	95.24	
Religion							
No religion	108	12.98	48	12.87	7	11.11	0.5986
Buddhist	287	34.50	141	37.80	21	33.33	
Taoism	300	36.06	137	36.73	27	42.86	
Others	137	16.47	47	12.60	8	12.70	
Socioeconomic factors							
Educational status							
Uneducated	35	4.21	54	14.48	14	22.22	<0.001
Primary School	236	28.37	154	41.29	27	42.86	
Junior School	132	15.87	47	12.60	9	14.29	
Senior High or above School	429	51.56	118	31.64	13	20.63	
Currently working							
Yes	224	26.92	57	15.28	2	3.17	<0.001
No	608	73.08	316	84.72	61	96.83	
Financial independence							
Yes	552	66.35	201	53.89	19	30.16	<0.001
No	280	33.65	172	46.11	44	69.84	
Recruitment settings							
Community	384	46.15	71	19.03	9	14.29	<0.001
Outpatient	418	50.24	239	64.08	34	53.97	
Inpatient	30	3.61	63	16.89	20	31.75	

[a] High, moderate, and low IC indicate 0, 1–2, and>=3 abnormality in functioning.

Table 2
Comparison of lifestyle, emotional disorder, and sleep health among older adults with various levels of intrinsic capacity.

	High IC		Moderate IC		Low IC		p value
	n = 832, 65.6%		n = 373, 29.4%		n = 63, 5.0%		
	n	%	n	%	N	%	
Lifestyle							
Smoking							
Yes	175	21.03	71	19.03	13	20.63	0.7280
No	657	78.97	302	80.97	50	79.37	
Alcohol consumption							
Yes	85	10.22	41	10.99	8	12.70	0.7857
No	747	89.78	332	89.01	55	87.30	
Chewing betel quid							
Yes	50	6.01	28	7.51	5	7.94	0.4805
No	782	93.99	345	92.49	58	92.06	
Mild exercise							
Yes	694	83.41	260	69.70	31	49.20	<0.001
No	138	16.59	113	30.30	32	50.80	
Vigorous exercise							
Yes	206	24.76	38	10.19	2	3.17	<0.001
No	626	75.24	335	89.81	61	96.83	
Emotional disorder							
Yes	32	3.85	36	9.65	9	14.29	<0.001
No	800	96.15	337	90.35	54	85.71	
Sleep health[a]							
Mean (SD)	10.07	2.28	9.11	2.70	7.68	3.07	<0.001

[a] A higher score is indicative of better health.

Table 3
Covariate-adjusted odds ratio and 95% confidence intervals of lower intrinsic capacity in relation to an increased total score of sleep health among older adults.

	Sleep Health Total Score	
	Odds Ratio	(95% CI)
Crude model	0.83	(0.79–0.86)
Adjusted model[a]	0.84	(0.80–0.88)
Adjusted model[b]	0.84	(0.80–0.88)
Adjusted model[c]	0.85	(0.81–0.89)
Adjusted model[d]	0.86	(0.82–0.90)
Adjusted model[e]	0.91	(0.86–0.96)

[a] Adjusted for demographic characteristics.
[b] Adjusted for demographic characteristics and socioeconomic factors.
[c] Adjusted for the demographic characteristics, socioeconomic factors, and lifestyle.
[d] Adjusted for the demographic characteristics, socioeconomic status, lifestyle, and emotional disorder.
[e] Adjusted for the demographic characteristics, socioeconomic factors, lifestyle, emotional disorder, and recruitment setting.

4. Discussion

A one-point increase in sleep health was significantly associated

Table 4
Odds ratio of lower intrinsic capacity in relation to an increased overall and item-specific sleep health scores.

	Crude OR		Adjusted[a] OR (full model)	
	OR	95% CI	OR	(95% CI)
Total score	0.83	(0.79–0.86)	0.91	(0.86–0.96)
Regularity	0.60	(0.48–0.74)	0.77	(0.60–0.99)
Satisfaction	0.66	(0.56–0.77)	0.83	(0.68–1.00)
Alertness	0.48	(0.40–0.57)	0.64	(0.52–0.79)
Timing	0.60	(0.50–0.72)	0.80	(0.65–0.99)
Efficiency	0.64	(0.54–0.75)	0.85	(0.70–1.03)
Duration	0.61	(0.51–0.74)	0.77	(0.61–0.96)

[a] Adjusted for the demographic characteristics, socioeconomic factors, lifestyle, emotional disorder, and recruitment setting.

with a 9% reduction in the odds of poor IC. When sleep health was broken down by subitem, we found that an increase in daytime alertness was related to the greatest reduction in poor IC.

Overall, our findings were consistent with previous reports that IC scores studies were significantly lower among older age groups, women, and those with lower levels of education and subjective social status [27–29]. Our study also consistently showed that older people who have emotional disorders, less regular exercise, and less vigorous exercise were more likely to have poor IC [29,30].

Our study showed that sleep health was positively and significantly associated with IC. To the best of our knowledge, this study is the first to report an association between sleep health and IC levels. One meta-analysis including 18 studies with 39,669 older participants highlighted the relationship between sleep disorders (daytime sleepiness, short sleep duration, long sleep duration, sleep latency extension, and sleep-disordered breathing) and a higher risk of frailty [31]. A previous review study demonstrated consistent evidence of the association between poor sleep quality and a higher risk of frailty, suggesting a need to incorporate assessments and interventions for improving sleep quality [6].

The analyses of associations between specific sleep health subitem and IC showed that a higher daytime alertness score showed the greatest reduction in the OR of poor IC. Such findings were consistent with the results from a 14-year long-term follow-up study [32], which found that longer and more frequent daytime naps were associated with a higher risk of Alzheimer's dementia. The study proposed that excessive napping and Alzheimer's dementia may have a bidirectional relationship or share common pathophysiological mechanisms [32]. In addition, a previous study using a representative national sample of older adults in Taiwan found that daytime alertness was significantly related to frailty in men but not in women [33]. Another prior study reported that cognitive impairment was positively associated with daytime sleep duration of 1 h or more [34]. However, a recent systematic review suggested a possible inverted U-shaped association between napping duration and cognitive health in older adults compared with non-napping and long or extended napping [35]. In addition, a study by Furihata et al. [36] also found that daytime sleepiness was most significantly associated with depression symptoms in their multi-dimensions measure of sleep health.

An increased score of sleep regularity and timing reduced the ORs of poor IC by 23% and 20%, respectively. An Australian study conducted a telephone survey to assess sleep history over the prior 24 h for adults aged more than 65 years [37]; it showed that sleep schedule regularity might be associated with sleep duration in older adults. Pye et al. found that older adults with current depression had a significantly lower sleep regularity index compared with healthy adults [38]. Total sleep time, sleep timing, and number of awakenings did not differ between groups, but a relationship was found between sleep irregularity and poor health in older adults [38].

This study revealed that a sleep duration of 6–8 h was associated with a 23% reduction in poor IC. Some studies noted that sleep duration had a U-shape relationship to adverse health effects, but others reported that longer sleep duration was better. Lauderdale et al. found sleeping less than 6 h per night was associated with poor or fair health among older people, but sleeping longer than average was not linked to any negative health consequences [39]. By contrast, Wang et al. surveyed elderly people and showed the significant association of longer sleep duration (>8 h) with slower normal walking gait speed in Chinese community residents [40]. One review also found long sleep duration was associated with increased markers of systemic inflammation, but not short sleep duration [41].

Given that sleep health was related to the level of IC, the specific mechanism connecting sleep parameters and IC remains uncertain. It is possible that inflammatory processes may explain the link between sleep health and IC. Disruptions to the sleep–wake cycle can affect inflammatory pathways, which may in turn affect the level of IC. Inflammation is one of the primary pathophysiological changes that may be associated with frailty [42]. Another potential explanation is that sleep problems are usually accompanied by depression in older people [43], which then results in lower IC. Leggett et al. also found that sleep disturbance and chronic medical conditions were associated with depressive symptoms [44]. Although we have managed to adjust emotional disorders in our study, such information was based on self-report, which could entail certain degrees of information bias. Incomplete adjustment for emotional disorders could render the play of emotional disorders in the relationship between sleep health and IC.

4.1. Strength and limitations

This study is the first to examine the relationship between sleep health and IC level in a geriatric population in Taiwan. Previous studies assessed sleep conditions and depressive symptoms as a psychological component of IC [12,45], in which participants were asked about the frequency of delay in falling asleep, inability to stay asleep, waking up tired, and disturbed sleep in the previous month. In the present study, we replaced the sleep condition with depression questions as our psychological component of IC to simplify the question and make it easier to answer. This approach also leaves room to examine the relationship between sleep health and IC level. Another strength is the recruitment of study participants from clinical and community settings, which increases the representativeness of older people. Lastly, many studies reported that an aggregate measures of sleep health has a stronger association with self-rated health scale than the individual dimensions of sleep health [36,46,47]. One study also concluded that using a broader range of sleep dimensions could be more useful than individual sleep measures for assessing health risks [47]. Despite the above strengths, some limitations should be mentioned. First, the cross-sectional design did not allow us to examine the temporal associations between sleep health and IC level, leading to difficulty in making specific interpretations of our findings. Second, the direction of the causality might be reversed, and poor sleep health could be caused by poor IC. Third, the measurement of behavior and sleep health was based on a self-reported questionnaire, which may entail certain information bias. Fourth, the Chinese version of RU-SATED has not been formally validated, but many studies reported the STATED scale was useful and easy to use [46,47]. In addition, we did not make a comprehensive adjustment for all potential confounders, such as diet, in our analyses. Lastly, the study sample was from one city only in Taiwan, which limits the generalizability of the findings.

4.2. Conclusion

Better overall sleep health was found to be associated with a significant reduction in poor IC among older people. When we stratified sleep health into each dimension, daytime alertness showed the strongest association with IC. Given that improvement in IC can predict better health outcomes, developing interventions that enhance the sleep health of older adults is essential in ensuring their IC.

Ethics approval and consent to participate

The study was approved by the institutional review board of the National Cheng Kung University Hospital (IRB No. A-ER-110-249). All participants and their legal guardians were informed about the study goals. Written informed consent was obtained from all participants or their legal guardians prior to the study enrollment according to the Declaration of Helsinki. Participants as well as their relatives or legal guardians could withdraw consent at any time.

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Role of funding source

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Availability of data and material

An anonymized dataset supporting the results of this study is available upon request.

CRediT authorship contribution statement

Ya-Hui Chang: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Yen-Chin Chen:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing. **Li-Jung Elizabeth Ku:** Data curation, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Yu-Tsung Chou:** Data curation, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Hung-Yu Chen:** Data curation, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Hui-Chen Su:** Data curation, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Chieh-Hsiu Liu:** Conceptualization, Funding acquisition, Methodology, Resources, Writing – review & editing. **Yi-Lin Wu:** Data curation, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Hsiang-Ju Cheng:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Yi-Ching Yang:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing. **Chung-Yi Li:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

Authors declare none.

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References

[1] Najafipour H, Sabahi A, Khoramipour K, et al. Prevalence, incidence and health impacts of sleep disorders on coronary artery disease risk factors: results of a community-based cohort study (KERCADRS). Iran J Psychiatry 2022;17(3):247–56.
[2] Smagula SF, Stone KL, Fabio A, Cauley JA. Risk factors for sleep disturbances in older adults: evidence from prospective studies. Sleep Med Rev 2016;25:21–30.
[3] Alfini AJ, Schrack JA, Urbanek JK, et al. Associations of actigraphic sleep parameters with fatigability in older adults. J Gerontol A Biol Sci Med Sci 2020;75(9):e95–102.
[4] Wang L, Zou B. The association between gait speed and sleep problems among Chinese adults aged 50 and greater. Front Neurosci 2022;16:855955.
[5] Atoui S, Chevance G, Romain AJ, Kingsbury C, Lachance JP, Bernard P. Daily associations between sleep and physical activity: a systematic review and meta-analysis. Sleep Med Rev 2021;57:101426.
[6] Wai JL, Yu DS. The relationship between sleep-wake disturbances and frailty among older adults: a systematic review. J Adv Nurs 2020;76(1):96–108.
[7] Magnavita N, Garbarino S. Sleep, health and wellness at work: a scoping review. Int J Environ Res Publ Health 2017;14(11):1347.
[8] Buysse DJ. Sleep health: can we define it? Does it matter? Sleep 2014;37(1):9–17.
[9] Hale L, Troxel W, Buysse DJ. Sleep health: an opportunity for public health to address health equity. Annu Rev Publ Health 2020;41:81–99.
[10] World Health Organization. World report on ageing and health. Available at: https://apps.who.int/iris/handle/10665/186463. [Accessed 9 June 2023].
[11] Liu S, Yu X, Wang X, et al. Intrinsic capacity predicts adverse outcomes using Integrated Care for Older People screening tool in a senior community in Beijing. Arch Gerontol Geriatr 2021;94:104358.
[12] Beard JR, Jotheeswaran AT, Cesari M, Araujo de Carvalho I. The structure and predictive value of intrinsic capacity in a longitudinal study of ageing. BMJ Open 2019;9(11):e026119.
[13] Zeng X, Shen S, Xu L, et al. The impact of intrinsic capacity on adverse outcomes in older hospitalized patients: a one-year follow-up study. Gerontology 2021;67(3):267–75.
[14] Zhou Y, Ma L. Intrinsic capacity in older adults: recent advances. Aging Dis 2022;13(2):353–9.
[15] Alqahtani BA. Association between physical frailty and sleep quality among Saudi older adults: a community-based, cross-sectional study. Int J Environ Res Publ Health 2021;18(23):12741.
[16] Shih AC, Chen LH, Tsai CC, Chen JY. Correlation between sleep quality and frailty status among middle-aged and older Taiwanese people: a community-based, cross-sectional study. Int J Environ Res Publ Health 2020;17(24):9457.
[17] Çavuşoğlu Ç, Deniz O, Tuna Doğrul R, et al. Frailty is associated with poor sleep quality in the oldest old. Turk J Med Sci 2021;51(2):540–6.
[18] Tay L, Tay EL, Mah SM, Latib A, Koh C, Ng YS. Association of intrinsic capacity with frailty, physical fitness and adverse health outcomes in community-dwelling older adults. J Frailty Aging 2023;12(1):7–15.
[19] Yu R, Leung J, Leung G, Woo J. Towards healthy ageing: using the concept of intrinsic capacity in frailty prevention. J Nutr Health Aging 2022;26(1):30–6.
[20] Belloni G, Cesari M. Frailty and intrinsic capacity: two distinct but related constructs. Front Med 2019;6:133.
[21] Ma L, Chhetri JK, Zhang Y, et al. Integrated care for older people screening tool for measuring intrinsic capacity: preliminary findings from ICOPE pilot in China. Front Med 2020;7:576079.
[22] Ravyts S, Dzierzewski J, Perez E, Donovan E. Validation and clinical usefulness of a sleep health scale in late life. Innovation in Aging 2019;3(S1):S526.
[23] Muneera K, Muhammad T, Althaf S. Socio-demographic and lifestyle factors associated with intrinsic capacity among older adults: evidence from India. BMC Geriatr 2022;22(1):851. 12.
[24] Su YJ, Hsu CT, Liang C, et al. Association between health-related physical fitness and self-reported health status in older Taiwanese adults. BMC Geriatr 2022;22(1):235.
[25] Hsu WC, Tsai AC, Chen YC, Wang JY. Predicted factors for older Taiwanese to be healthy octogenarians: results of an 18-year national cohort study. Geriatr Gerontol Int 2017;17(12):2579–85.
[26] Bao YP, Han Y, Ma J, et al. Cooccurrence and bidirectional prediction of sleep disturbances and depression in older adults: meta-analysis and systematic review. Neurosci Biobehav Rev 2017;75:257–73.
[27] Yu R, Thiyagarajan JA, Leung J, Lu Z, Kwok T, Woo J. Validation of the construct of intrinsic capacity in a longitudinal Chinese cohort. J Nutr Health Aging

2021;25:808–15.
[28] Gutiérrez-Robledo LM, García-Chanes RE, Pérez-Zepeda MU. Allostatic load as a biological substrate to intrinsic capacity: a secondary analysis of CRELES. J Nutr Health Aging 2019;23(9):788–95.
[29] Ma L, Chhetri JK, Zhang L, Sun F, Li Y, Tang Z. Cross-sectional study examining the status of intrinsic capacity decline in community-dwelling older adults in China: prevalence, associated factors and implications for clinical care. BMJ Open 2021;11(1):e043062.
[30] Ma L, Liu P, Zhang Y, Sha G, Zhang L, Li Y. High serum tumor necrosis factor receptor 1 levels are related to risk of low intrinsic capacity in elderly adults. J Nutr Health Aging 2021;25(4):416–8.
[31] Sun R, Xie Y, Jiang W, Wang E, Li X. Effects of different sleep disorders on frailty in the elderly: a systematic review and meta-analysis of observational studies. Sleep Breath 2023;27(1):91–101.
[32] Li P, Gao L, Yu L, et al. Daytime napping and Alzheimer's dementia: a potential bidirectional relationship. Alzheimers Dement 2023;19(1):158–68.
[33] Chen TY, Lee S, Buxton OM. Multidimensional sleep health is associated with physical frailty in a national sample of Taiwanese community-dwelling older adults: sex matters. Sleep Health 2022;8(5):528–35.
[34] Ohayon MM, Vecchierini MF. Normative sleep data, cognitive function and daily living activities in older adults in the community. Sleep 2005;28(8):981–9.
[35] Li J, McPhillips MV, Deng Z, Fan F, Spira A. Daytime napping and cognitive health in older adults: a systematic review. J Gerontol A Biol Sci Med Sci 2022: glac239. https://doi.org/10.1093/gerona/glac239 [Epub ahead of print].
[36] Furihata R, Hall MH, Stone KL, et al. An Aggregate measure of sleep health is associated with prevalent and incident clinically significant depression symptoms among community-dwelling older women. Sleep 2017;40(3):zsw075.
[37] Paterson JL, Reynolds AC, Dawson D. Sleep schedule regularity is associated with sleep duration in older Australian adults: implications for improving the sleep health and wellbeing of our aging population. Clin Gerontol 2018;41(2):113–22.
[38] Pye J, Phillips AJ, Cain SW, et al. Irregular sleep-wake patterns in older adults with current or remitted depression. J Affect Disord 2021;281:431–7.
[39] Lauderdale DS, Chen JH, Kurina LM, Waite LJ, Thisted RA. Sleep duration and health among older adults: associations vary by how sleep is measured. J Epidemiol Community Health 2016;70(4):361–6.
[40] Wang HY, Zhang J, Li J, et al. Analysis of intrinsic capacity and influencing factors in community-dwelling elderly people. Chinese Journal of Geriatrics 2022;(12):591–5.
[41] Irwin MR, Olmstead R, Carroll JE. Sleep disturbance, sleep duration, and inflammation: a systematic review and meta-analysis of cohort studies and experimental sleep deprivation. Biol Psychiatr 2016;80(1):40–52.
[42] Chen X, Mao G, Leng SX. Frailty syndrome: an overview. Clin Interv Aging 2014;9:433–41.
[43] Lee E, Cho HJ, Olmstead R, Levin MJ, Oxman MN, Irwin MR. Persistent sleep disturbance: a risk factor for recurrent depression in community-dwelling older adults. Sleep 2013;36(11):1685–91.
[44] Leggett A, Assari S, Burgard S, Zivin K. The Effect of sleep disturbance on the association between chronic medical conditions and depressive symptoms over time. Longit Life Course Stud 2017;8(2):138–51.
[45] Aliberti MJR, Bertola L, Szlejf C, et al. Validating intrinsic capacity to measure healthy aging in an upper middle-income country: findings from the ELSI-Brazil. Lancet Reg Health Am 2022;27(12):100284.
[46] Appleton SL, Melaku YA, Reynolds AC, Gill TK, de Batlle J, Adams RJ. Multidimensional sleep health is associated with mental well-being in Australian adults. J Sleep Res 2022;31(2):e13477.
[47] Dalmases M, Benítez ID, Mas A, et al. Assessing sleep health in a European population: results of the Catalan Health Survey 2015. PLoS One 2018;13(4):e0194495.