scientific reports

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Associations of afternoon naps with progression of advanced cardiovascular-kidney-metabolic syndrome among Chinese adults aged 45 years and above

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Cardiovascular-kidney-metabolic (CKM) syndrome poses a significant and growing public health challenge. While sleep disturbances are recognized as a risk factor, the role of daytime napping in the progression of CKM syndrome remains unclear. We utilized data from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative cohort. This study included 9,810 participants for cross-sectional analysis and 4,990 participants free of advanced CKM syndrome at baseline for longitudinal analysis. Nap duration was categorized into four groups: 0, 1–29, 30–89, and ≥ 90 min. Advanced CKM syndrome (stages 3–4) was defined according to the American Heart Association criteria. Multivariable logistic regression models were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs). In the longitudinal analysis, a short afternoon nap (1–29 min) was associated with a 35.3% reduction in the risk of incident advanced CKM syndrome compared to non-napping (adjusted OR = 0.647, 95% CI 0.451–0.928). This protective association was particularly significant in males (OR = 0.645, 95% CI 0.432–0.964) and individuals who were married or partnered (OR = 0.734, 95% CI 0.545–0.988). Furthermore, for older adults over 60 years of age, a moderate nap duration (30–89 min) was also linked to a lower risk (OR = 0.664, 95% CI 0.476–0.927). The cross-sectional analysis yielded consistent results. Sensitivity analyses confirmed the robustness of these findings. Short afternoon napping is associated with a reduced risk of developing advanced CKM syndrome in middle-aged and older Chinese adults, highlighting its potential as a target for primary prevention strategies aimed at mitigating CKM syndrome risk in an aging population.

Keywords Afternoon nap, Cardiovascular-kidney-metabolic (CKM) syndrome, Middle-aged and older adults, Perspective cohort analysis

Cardiovascular-kidney-metabolic (CKM) syndrome, a health disorder recently defined by the American Heart Association (AHA) in 2023, is characterized by the connections among metabolic dysfunction, chronic kidney disease (CKD), and cardiovascular disease (CVD)[1]. Till now, CKM syndrome poses a significant and growing public health challenge. In the United States, an estimated 208 million adults (nearly 90%) meet criteria for at least stage 1 CKM syndrome, with 33 million (15%) progressing to advanced stages 3–4[3]. The situation is particularly acute in China, where 26.5% of middle-aged and older adults are affected by advanced CKM syndrome[2]. This high prevalence contributes to substantial morbidity, premature mortality, and a heavy social and economic burden[1,3]. Notably, individuals at these advanced stages face significantly elevated mortality risks compared to those in earlier stages[4,5]. Given this escalating global burden, identifying and addressing modifiable risk factors that accelerate progression to advanced CKM syndrome is of paramount importance for developing targeted prevention and intervention strategies[1,6].

Beyond the risk factors traditionally used to establish CKM syndrome stage constructs, accumulating evidence highlights that additional modifiable factors, including adverse social determinants of health, mental health disorders, and sleep disturbance, could elevate the risk of progressing along CKM syndrome stages[1,6].

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Recently, the role of sleep disorders, such as insomnia, sleep apnea, and circadian rhythm disruptions, has been drawing significant attention among CKM patients[7]. Accumulating evidence has demonstrated that unhealthy sleep behaviors enhance the risk of CKM-related components, such as obesity, diabetes, kidney failure, and CVD[8–11]. In contrast, napping, a common daytime rest behavior, is considered a healthy lifestyle habit and enjoys widespread popularity in many parts of the world, particularly in China[12]. Given the prevalence of afternoon napping among older adults, an increasing number of studies have focused on its relationship with cardiometabolic health. A previous study demonstrated that individuals who nap once or twice per week exhibit a reduced risk of incident CVD events[13], but long daytime napping (≥ 1 h/d) was associated with higher risk of CVD and mortality[14]. Most recently, another cross-sectional study has also concluded that among patients with CKM syndrome, those reporting higher overall sleep quality were less likely to progress to advanced stages[15]. However, other studies indicated that daytime napping is associated with elevated risks of diabetes[16] and CKD[17]. Therefore, the inconsistency in conclusions highlights the need for further studies to clarify whether recovery sleep (e.g., short afternoon naps) could help mitigate CKM syndrome risks.

Hence, utilizing data from the China Health and Retirement Longitudinal Study (CHARLS), this study aimed to investigate the association between afternoon nap duration and the risk of advanced CKM syndrome, in order to determine whether napping habits could be a potential target for intervention.

Methods

Study population

The China Health and Retirement Longitudinal Study (CHARLS) is a nationally representative longitudinal survey initiated in 2011, collecting high-quality data from Chinese people through one-on-one interviews and a structured questionnaire. The study was conducted in five waves, starting in 2011 and followed up in 2013, 2015, 2018, and 2020. The details of its study design were reported previously[18]. The study protocol was approved by the Institutional Review Board of Peking University (IRB00001052-11015), and written informed consent was obtained from all participants.

In this study, we utilized data from the 2011 (wave 1) and the 2015 (wave 3), as both waves included comprehensive anthropometric measurements (e.g., height, weight, BMI) and blood biochemical markers essential for longitudinal examination of CKM health parameters. Specifically, exclusion criteria were as follows: (1) individuals under 45 years of age; (2) missing waist circumference measurements and BMI data; (3) missing information on duration of napping; (4) missing information on hypertension, dyslipidemia, diabetes, CVD and CKD. For longitudinal analysis, we further excluded participants with pre-existing CKM syndrome at wave 1. The final population studied comprised 9,810 participants for cross-sectional analysis and 4,990 for longitudinal analysis. A detailed flow diagram depicting the inclusion and exclusion process is presented (Fig. 1).

Assessment of daytime nap duration

The duration of napping was evaluated on the basis of the answers to the following question: "In the past month, how long did you take a nap after lunch?" This question was considered to have high reliability and validity in

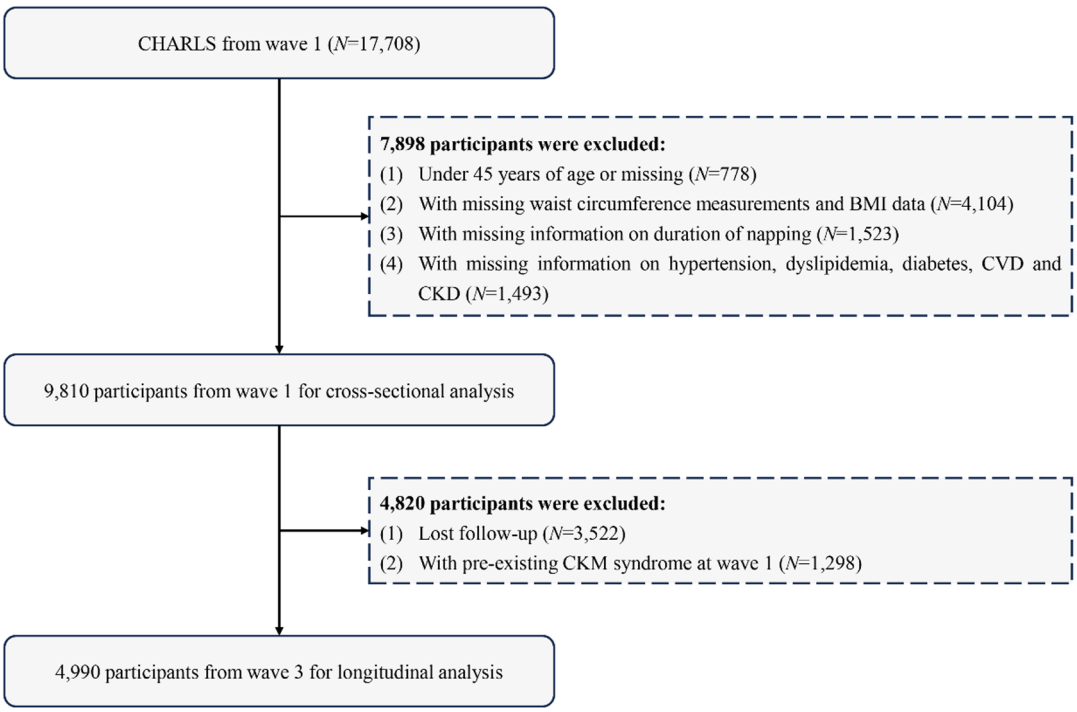

Fig. 1. Flowchart of the study population.

determining the duration of napping[19]. In accordance with previous studies[19,20], this work divided participants into four groups on the basis of napping status: 0 min a day; < 30 min a day (excluding 0 min); 30–89 min a day; ≥ 90 min per day.

Definition of CKM syndrome

In this study, CKM syndrome stages for CHARLS participants were defined according to the American Heart Association (AHA) Presidential Advisory, which classifies the syndrome into five stages (0–4) based on the coexistence of subclinical or clinical CVD, CKD, and metabolic disorders[1]. The detailed definition is presented in S1 Table. In brief, stage 0 represented no identifiable CKM syndrome risk factors, such as overweight (BMI ≥ 23 kg/m^2), dyslipidemia, or prediabetes, and no evidence of CKD/CVD. Stage 1 is characterized by overweight or abdominal obesity (BMI ≥ 23 kg/m² or waist circumference ≥ 90/80 cm for men/women) without other metabolic risk factors. Stage 2 includes individuals with metabolic risk factors (e.g., hypertension, diabetes, hypertriglyceridemia ≥ 135 mg/dL) or moderate-to-high-risk CKD, as determined by the KDIGO classification[21]. Stage 3 comprises those with subclinical CVD or a high predicted 10-year CVD risk, for which we used the PREVENT equations according to previous studies (S2 Table)[22,23]. Finally, stage 4 was characterized by the existence of clinical CVD, including heart failure, atrial fibrillation, coronary heart disease, and stroke. CKM syndrome stages 3 and 4 are recognized as advanced based on their association with either confirmed CVD or significantly elevated CVD risk profiles[3].

Ascertainment of covariates

At baseline, professionally trained clinicians and nurses used standardized structured questionnaires to collect data on potential covariates, including general demographic and lifestyle factors. General demographic factors include age (continuous), Gender (male; female), marital status (married or partnered; others) and education (primary school or lower, higher than primary school). Lifestyle factors include smoking (yes, no), and drinking (yes, no)[24]. Missing values were imputed by technology of Multivariate Imputation by Chained Equations (MICE)[25].

Statistical analysis

A descriptive analysis was performed on the baseline characteristics. Descriptions for continuous variables were presented as means with standard deviations (SD) and were compared with *t*-tests. Categorical variables were presented as frequencies with percentage and were analyzed using chi-squared tests. In both cross-sectional and longitudinal analyses, we conducted multivariable logistic regression to assess the effect of afternoon naps on advanced CKM syndrome, with odd radios (ORs) and 95% confidence interval (CIs) being represented. Three models were constructed to validate the results: Model 1 included adjustments for age and sex; Model 2 additionally adjusted for education level, and marital status based on Model 1; Model 3 additionally included adjustments for smoking status, alcohol consumption based on Model 2. Furthermore, to explore the differences of associations between subgroups, we performed stratified analysis in the longitudinal cohort. The participants were divided into different subgroups according to age (< 60 years and ≥ 60 years), sex, education level, marital status, smoking status, and alcohol consumption status. Furthermore, to validate the robustness of the study results, we conducted several sensitivity analyses in the longitudinal cohort: (1) further adjusting for physical activity; (2) further adjusting for occupational status; (3) restricting the analysis to participants with complete data on all covariates. All the statistical analyses were performed via R (version 4.4.2). All *P* values were two-sided, with significance level as 0.05.

Results

General characteristics of the participants

Our study involved a total of 9810 participants in the cross-sectional analysis and 4990 participants in the longitudinal analysis. In the cross-sectional analysis, 7537 participants were categorized as the non-advanced CKM syndrome group, while 2273 participants were classified into the advanced CKM syndrome group. The mean (SD) duration of afternoon napping was 36.2 (44.2) minutes in the non-advanced group and 31.8 (42.8) minutes in the advanced group, respectively. For the longitudinal analysis, participants initially in the non-advanced CKM syndrome group at baseline (N = 4,990) were followed over time, with 379 individuals further developing to advanced CKM syndrome. The mean (SD) duration of afternoon nap in the longitudinal analysis was 37.6 (46.5) and 31.2 (42.7) minutes for non-advanced CKM syndrome group and advanced CKM syndrome group, respectively. Detailed descriptive characteristics of the study population are summarized in Table 1. Notably, participants with advanced-stage CKM syndrome tended to characterize by older age, male sex, marital status (married or partnered), lower educational attainment, and a history of smoking or alcohol consumption (Table 1).

Associations of afternoon naps on advanced CKM syndrome risk

Compared with non-napping, taking an afternoon nap, particularly a short one, was associated with a significantly lower risk of developing advanced CKM syndrome, after controlling for multiple covariates in a logistic regression model. In the cross-sectional analysis, compared to the non-napping group, the risk of advanced CKM syndrome was reduced to 64.3% (95% CI: 53.5%~77.2%) in the 1–29 min group, 78.3% (95% CI: 69.0%~88.7%) in the 30–89 min group, and 79.5% (95% CI: 67.7%~93.3%) in the ≥ 90 min group, with all covariates adjusted. For the longitudinal analysis, participants initially free of advanced CKM syndrome at wave 1 showed a 35.3% risk reduction (adjusted OR = 0.647, 95% CI: 0.451 ~ 0.928) to develop advanced CKM syndrome when taking a 1–29 min afternoon nap. However, no statistically significant associations were observed

Variables	Cross-sectional analysis (*N* = 9,810)			Longitudinal analysis (*N* = 4,990)		
	Non-advanced CKM syndrome (*N* = 7,537)	Advanced CKM syndrome (*N* = 2,273)	*P*	Non-advanced CKM syndrome (*N* = 4,611)	Advanced CKM syndrome (*N* = 379)	*P*
Afternoon nap (min)	36.2 (44.2)	31.8 (42.8)	< 0.001	37.6 (46.5)	31.2 (42.7)	0.010
Afternoon nap			< 0.001			0.045
0 min	3,090 (41.0%)	1,100 (48.4%)		1,960 (42.5%)	185 (48.7%)	
1–29 min	829 (11.0%)	201 (8.9%)		512 (11.1%)	36 (9.4%)	
30–89 min	2,434 (32.3%)	662 (29.1%)		1,337 (29.0%)	108 (28.6%)	
≥ 90 min	1,183 (15.7%)	309 (13.6%)		802 (17.4%)	51 (13.4%)	
Age	57.3 (7.85)	67.1 (10.3)	< 0.001	56.3 (6.93)	68.6 (5.79)	< 0.001
Sex			< 0.001			< 0.001
Female	4,140 (54.9%)	1,101 (48.4%)		2,596 (56.3%)	170 (44.9%)	
Male	3,397 (45.1%)	1,172 (51.6%)		2,015 (43.7%)	209 (55.1%)	
Marriage status			< 0.001			< 0.001
Others	731 (9.70%)	495 (21.8%)		364 (7.89%)	74 (19.5%)	
Married or partnered	6,806 (90.3%)	1,778 (78.2%)		4,247 (92.1%)	305 (80.5%)	
Education level			< 0.001			< 0.001
Primary school or lower	5,159 (68.4%)	1,753 (77.1%)		3,122 (67.7%)	315 (83.1%)	
Higher than primary school	2,378 (31.6%)	520 (22.9%)		1,489 (32.3%)	64 (16.9%)	
Smoking			< 0.001			0.261
No	4,717 (62.6%)	1,091 (48.0%)		2,889 (62.7%)	130 (34.3%)	
Yes	2,820 (37.4%)	1,182 (52.0%)		1,722 (37.3%)	249 (65.7%)	
Drinking			< 0.001			< 0.001
No	5,253 (69.7%)	708 (31.1%)		3,235 (70.2%)	130 (34.3%)	
Yes	2,284 (30.3%)	1,565 (68.9%)		1,376 (29.8%)	249 (65.7%)	

Table 1. Baseline characteristics of participants included.

in longer nap duration groups, including the 30–89 min group (adjusted OR = 0.897, 95% CI: 0.494 ~ 1.628) and the ≥ 90 min group (adjusted OR = 0.728, 95% CI: 0.526 ~ 1.009) (Fig. 2).

Subgroup analyses

Subgroup analyses for longitudinal analysis suggested that, none of the subgroups, including age, sex, marital status, education level, smoking status, or alcohol consumption, altered the relationship between napping and risk of advanced CKM syndrome (*P* for interaction > 0.05). These findings indicated the effect of napping was robust and did not statistically differ between these groups. Despite the non-significant interactions, the exploratory results within each stratum indicated that, compared to non-nappers, individuals taking a short afternoon nap (1–29 min) exhibited reduced incidence risk of advanced CKM syndrome among male participants (OR = 0.645, 95%CI: 0.432 ~ 0.964) and those in married or partnered status (OR = 0.734, 95%CI: 0.545 ~ 0.988). A similar trend was observed for moderate napping (30–89 min) and reduced risk in individuals aged over 60 years (OR = 0.664, 95%CI: 0.476 ~ 0.927) (Table 2). Given the lack of significant interaction, these stratum-specific findings require more confirmation in future studies.

Sensitivity analyses

Sensitivity analyses for longitudinal analysis revealed no substantial change in the association between napping and advanced CKM syndrome risk after additionally adjusting for physical activity or occupational status based on Model 3, and when restricting to participants with complete data on all covariates (S3 Table).

Discussion

In this study, we found that taking a nap was associated with reduced risk of advanced CKM syndrome, both in cross-sectional analysis and longitudinal analysis. Moreover, taking a short napping (1–30 min) was found to be associated with a lower risk of incidence advanced CKM syndrome. Notably, a short nap (1–29 min) was associated with a lower incidence of advanced CKM syndrome, especially for males and married or partnered individuals, while for older adults over 60, a moderate nap (30–89 min) also conferred a protective effect. Our findings may provide beneficial insights of a common daytime rest behavior, napping, thereby contributing to strategies for the prevention of advanced CKM syndrome.

Our findings indicate that a short nap (1–29 min) was associated with a 35.3% reduction in the risk of developing advanced CKM syndrome among individuals who were free of the condition at baseline. While limited research has directly investigated this link, our results align with previous studies showing associations between napping and its related components, such as incident cardiovascular disease (CVD)[13,14]. Conversely, excessive napping may be detrimental. For instance, naps lasting one hour or more per day have been linked to a higher risk of diabetes, CVD and mortality[14,26,27]. Similarly, a systematic review including 44 cohort studies with 1.8 million subjects also recommended shortening the daily nap duration to no more than 30 min[28]. Therefore,

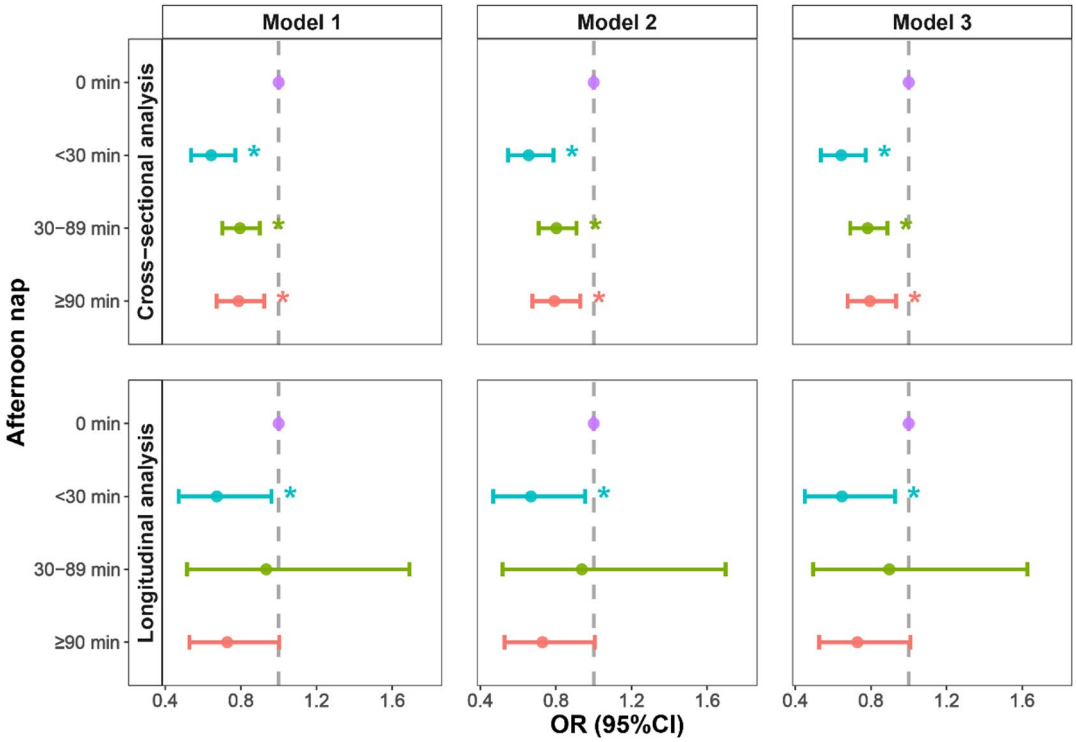

Fig. 2. The associations between afternoon nap and risk of advanced CKM syndrome. Model 1 included adjustments for age and sex; Model 2 additionally adjusted for education level, and marital status based on Model 1; Model 3 additionally included adjustments for smoking status, alcohol consumption based on Model 2.

Subgroups	Afternoon nap				*P* for interaction
	0 min	1–29 min	30–89 min	≥90 min	
Age < 60	Ref	0.651 (0.231, 1.833)	0.425 (0.160, 1.129)	0.888 (0.288, 2.740)	0.292
Age ≥ 60	Ref	0.760 (0.507, 1.142)	0.664 (0.476, 0.927)	0.820 (0.622, 1.08)	
Female	Ref	0.971 (0.552, 1.709)	0.987 (0.676, 1.441)	0.792 (0.497, 1.266)	0.652
Male	Ref	0.645 (0.432, 0.964)	0.641 (0.401, 1.024)	0.813 (0.575, 1.151)	
Married or partnered	Ref	0.734 (0.545, 0.988)	0.858 (0.649, 1.134)	0.727 (0.518, 1.019)	0.469
Others	Ref	0.932 (0.360, 2.410)	0.863 (0.472, 1.577)	0.699 (0.476, 1.027)	
Primary school or lower	Ref	0.759 (0.504, 1.144)	0.835 (0.633, 1.103)	0.500 (0.238, 1.053)	0.699
Higher than primary school	Ref	0.712 (0.483, 1.050)	0.774 (0.417, 1.435)	0.717 (0.343, 1.502)	
Non-smoking	Ref	0.917 (0.791, 1.066)	0.949 (0.692, 1.300)	0.712 (0.483, 1.050)	0.308
Smoking	Ref	0.964 (0.489, 1.901)	0.699 (0.455, 1.072)	0.928 (0.814, 1.057)	
Non-drinking	Ref	0.787 (0.505, 1.227)	0.950 (0.693, 1.301)	0.898 (0.658, 1.224)	0.721
Drinking	Ref	0.670 (0.368, 1.220)	0.746 (0.486, 1.145)	0.723 (0.428, 1.221)	

Table 2. Subgroup analyses of the association between afternoon nap and risk of advanced CKM syndrome.

it is advocating for short daytime naps, highlighting daytime napping as a potential, low-cost behavioral intervention for the primary prevention of advanced CKM syndrome.

The precise mechanisms linking afternoon napping to advanced CKM syndrome remain incompletely understood. Napping may serve as a compensatory mechanism to mitigate the deleterious effects of sleep deprivation[29]. However, when nighttime sleep is sufficient, longer naps are associated with adverse cardiometabolic outcomes[27]. On the beneficial side, short habitual naps offer multiple advantages, including improving circadian rhythms[20], restoring immune function[30], reducing oxidative and muscular damage from sleep loss[31], and offering neuroprotection that delays cerebral atrophy[32]. In contrast, prolonged napping could be detrimental by disrupting circadian rhythms, increasing endogenous glucocorticoid secretion[33], and heightening sympathetic activity, which in turn activates the renin-angiotensin system[34]. In addition, excessive daytime naps may be a marker for poor nocturnal sleep or short nighttime sleep, which is the true driver of CKM risk[15,35].

Ultimately, the effect of napping is likely a balance between these positive and negative influences, which may be further modulated by individual factors such as sex, age, and follow-up duration[28].

The study exhibits several methodological strengths. First, it leveraged a large-scale, nationally representative sample of Chinese middle-aged and older adults, enhancing the generalizability of findings to this demographic population. Second, we employed both cross-sectional and longitudinal to provide a comprehensive understanding of the relationship between daytime napping and advanced CKM syndrome risk. Additionally, comprehensive subgroup and sensitivity analyses were conducted to systematically evaluate the robustness of this association under varying conditions.

However, several limitations warrant acknowledgment. First, nap duration data relied solely on self-reporting, without objective validation via actigraphy or polysomnography, which may introduce measurement inaccuracies. Similarly, other covariates such as smoking and alcohol consumption were also self-reported, potentially leading to recall bias in the dataset. Second, the study lacked detailed information on critical aspects of habitual napping beyond duration, such as napping frequency and posture (e.g., lying in bed vs. leaning on a desk). Third, although we adjusted for several key covariates, more factors on certain lifestyle factors that may influence both napping and CKM risk should be acknowledged, such as daytime activities (e.g., social engagement, hobbies), nighttime sleep (both duration and quality) and dietary habits. Forth, as an observational study, residual confounding could not be entirely ruled out despite adjusting for multiple key confounders. Fifth, the focus on individuals aged ≥ 45 years restricts the applicability of findings to younger populations or other national contexts. Finally, the substantial loss to follow-up in the CHARLS dataset required further researches across other cohorts and more diverse populations to validate and expand these results.

Conclusions

In conclusion, this study indicates that short afternoon napping is associated with a reduced risk of incidence of advanced CKM syndrome, especially for males, married or partnered individuals and older adults over 60. This research provides novel insights into a common lifestyle behavior, highlighting its potential as a target for primary prevention strategies aimed at mitigating CKM syndrome risk in an aging population.

Data availability

The data in the article can be obtained from the CHARLS database (https://charls.pku.edu.cn/). The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Received: 22 October 2025; Accepted: 15 December 2025
Published online: 19 December 2025

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Author contributions

Conceptualization, B.C. and Z.D.; Study design, B.C. and B.M.; Manuscript draft, B.C. and S.W.; Draft review and editing, All authors.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-32994-9.

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