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Short Communication

Associations of eating duration and shift work with accelerated biological aging among U.S. workers

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ABSTRACT

Objectives: Eating duration and shift work can both influence circadian rhythm, which is crucial for longevity. However, their joint associations on the aging process remain unexplored. We aimed to examine the independent and joint associations of eating duration and shift work with accelerated biological aging (ABA) in a representative sample of U.S. workers.
Design and setting: A cross-sectional study using data from the National Health and Nutrition Examination Survey (NHANES), 2005–2010 and 2017–2018.
Participants: We included 10,211, 10,062, and 9,572 workers in eating duration, shift work, and joint association analyses, respectively.
Measurements: Time of eating occasions were accessed by 24-h dietary recalls, and eating duration was categorized as short (SED: <12 h), moderate (MED: 12−14 h; reference), and long eating duration (LED: ≥14 h). Work schedules were self-reported and classified as shift work (SW) vs. non-shift work (NSW). ABA was defined as biological age exceeding chronological age using the residual method. Adjusted Poisson regressions were used to examine the independent and joint associations.
Results: Eating duration had a U-shaped relationship with ABA. SED (PR, 1.13; 95%CI, 1.01–1.27) and LED (PR, 1.07; 95%CI, 0.96–1.19) were associated with higher prevalences of ABA compared to MED. SW was independently associated with a higher prevalence of ABA (PR, 1.10; 95%CI, 1.01–1.20). Workers with both SED and SW had an increased prevalence of ABA (PR, 1.19; 95%CI, 1.02–1.40) compared to those with MED and NSW.
Conclusions: We found that both eating duration and shift work independently and jointly increased the prevalence of accelerated biological aging among U.S. workers.

1. Introduction

Older workers consist of a growing segment of U.S. workforce. Employed workers older than 65 years has increased by 117% over the past two decades [1], and nearly one fourth of workers was over age 55 in 2021 [2]. This demographic shift poses challenges for occupational health, as aging workers can experience increased risks of chronic diseases. People experience accelerated biological aging (ABA) when biological age advances faster than chronological age. Biological aging, accumulation of damage with age at the molecular level, can powerfully predict age-related morbidity and mortality [3], and it is modifiable by lifestyle factors [4,5]. Understanding modifiable risk factors to prevent ABA is essential to extend healthy lifespan in the aging workforce.

Eating duration and shift work schedules can affect circadian alignment through inflammatory pathways and metabolic dysregulation [6,7], which are factors implicated in biological aging. Only a few observational studies have examined the independent associations of night fasting duration (i.e., the opposite measure of eating duration) [8] or shift work with biological aging [9–13], but their interplay remains poorly understood. Shift workers can have extended eating windows [14], potentially compounding circadian misalignment and accelerating biological aging.

Abbreviations: ABA, Accelerated biological aging; BMI, Body mass index; ED, Eating duration; LED, Long eating duration; MED, Moderate eating duration; NHANES, National Health and Nutrition Examination Survey; NSW, Non-shift work; SW, Shift work; SED, Short eating duration.

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The objective of this study was to investigate the independent and joint associations of eating duration and shift work with ABA, in a nationally representative sample of U.S. workers.

2. Methods

2.1. Study population

The National Health and Nutrition Examination Survey (NHANES) is an ongoing series of cross-sectional surveys, utilizing a complex sampling design and combining interviews, physical examinations, and laboratory tests [15]. The NHANES protocol was approved by the National Center for Health Statistics Research Ethics Review Board, and all study participants provided written informed consent. This study received an exemption from the Institutional Review Board at the University of California, Los Angeles. We used data from 2005 to 2010 and 2017 to 2018 cycles and included employed, non-pregnant individuals over 18 years old. In total, 10,211, 10,062, and 9,572 workers were included for eating duration, shift work, and joint association analyses, respectively. The flowchart for participants selection was shown in Figure S1.

2.2. Eating Duration (ED) assessment

Dietary intake was evaluated by two 24-h dietary recalls, using the United States Department of Agriculture's Automated Multiple-Pass Method [16]. The first recall was conducted in person, followed by a second recall via telephone 3–10 days later. Following established method, ED was calculated as the difference between the first (after 5:00 AM) and last (before 4:59 AM) eating occasions [17].

2.3. Shift work assessment

Work schedules were assessed by the Occupation Questionnaire. Individuals who reported working on early morning, evening/night, or rotating shifts were categorized as engaging in "Shift Work (SW)", while working during regular daytime hours or 9 AM-5 PM was classified as "Non-Shift Work (NSW)" [18]. We removed participants who reported "unknown" or "another schedule" from primary analysis due to insufficient clarification.

Table 1
Participant characteristics by eating duration and work schedule categories among U.S. workers[1,2].

Characteristics	Eating duration (N = 10,211)				Work schedule (N = 10,062)		
	<12 h (SED) (N = 3,336)	12–14 h (MED) (N = 5,070)	≥14 h (LED) (N = 1,805)	P-value	Non-shift Work (N = 6,872)	Shift Work (N = 3,190)	P-value
Age, year	38 (0.3)	42 (0.4)	44 (0.4)	<0.001	43 (0.2)	39 (0.4)	<0.001
Female, %	1620 (48)	1732 (49)	1274 (40)	<0.001	3125 (47)	1441 (44)	0.13
Race/ethnicity, %				<0.001			<0.001
Mexican American	765 (12)	735 (9)	538 (7)		1463 (9)	592 (10)	
Other Hispanic	356 (6)	318 (5)	270 (4)		644 (5)	327 (7)	
Non-Hispanic White	1149 (60)	1620 (70)	1603 (75)		3065 (71)	1085 (60)	
Non-Hispanic Black	824 (14)	668 (9)	526 (7)		1211 (9)	791 (13)	
Others	242 (8)	316 (7)	281 (6)		489 (7)	395 (9)	
Poverty-income-ratio, %				<0.001			<0.001
<1.30	1161 (25)	1016 (18)	759 (17)		1819 (17)	1148 (27)	
1.30−3.50	1231 (34)	1256 (30)	1110 (31)		2372 (31)	1207 (35)	
≥3.50	944 (41)	1385 (52)	1349 (53)		2681 (52)	835 (37)	
Education, %				<0.001			<0.001
Less than high school	839 (15)	764 (12)	578 (11)		1535 (13)	681 (13)	
High school graduate	878 (29)	795 (21)	724 (23)		1525 (22)	861 (30)	
Some college or above	1613 (56)	2098 (67)	1914 (66)		3806 (64)	1647 (57)	
Marital status, %				<0.001			<0.001
Never married	919 (30)	654 (17)	523 (17)		1224 (16)	870 (28)	
Widowed/divorced/separated	463 (13)	575 (15)	548 (17)		1044 (14)	494 (14)	
Married/living with partner	1777 (57)	2328 (68)	2099 (66)		4468 (69)	1632 (57)	
Smoking status, %				<0.001			0.002
Current smoker	640 (21)	674 (19)	740 (24)		1343 (20)	699 (24)	
Former smoker	518 (18)	807 (24)	735 (24)		1415 (23)	560 (22)	
Never smoker	1911 (61)	2031 (57)	1682 (52)		3899 (58)	1689 (55)	
Alcohol use, %				0.26			<0.001
None	882 (24)	969 (22)	858 (23)		1889 (26)	730 (21)	
Moderate	2017 (74)	2369 (76)	2123 (74)		4355 (73)	1948 (74)	
Heavy	47 (2)	44 (2)	61 (3)		54 (1)	107 (5)	
Sleep duration, %				<0.001			<0.001
<7 h	1114 (31)	1185 (28)	1330 (38)		2431 (33)	1100 (31)	
7−9 h	1887 (59)	2179 (65)	1720 (57)		4078 (62)	1637 (56)	
≥9 h	335 (10)	293 (8)	168 (5)		363 (5)	453 (14)	
Physically active, %	1829 (54)	1998 (55)	1726 (53)	0.45	3720 (55)	1836 (57)	0.22
Body mass index, kg/m^2	28.6 (0.2)	28.8 (0.2)	28.6 (0.2)	0.75	28.7 (0.1)	29.0 (0.2)	0.01
Total energy intake, kcal	2025.0 (18.6)	2182.3 (17.2)	2374.2 (24.7)	<0.001	2252.5 (16.9)	2194.7 (19.1)	0.07

Abbreviations: LED, long eating duration; MED, moderate eating duration; SED, short eating duration.

[1] Analyses accounted for the NHANES complex survey design. Categorical variables were presented as unweighted frequency (weighted percentage) and continuous variables were presented as weighted mean (weighted standard error). P-values were calculated from Chi-Square test for categorical variables and Analysis of Variance (ANOVA) for continuous variables.

[2] In NHANES, socio-demographic and lifestyle factors were collected through computer-assisted personal interviews, including age (years), sex (male vs. female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Mexican American, Hispanic, others), education (less than high school, high school or equivalent, college or above), marital status (never married, widowed/divorced/separated, married/living with partner), poverty-income-ratio (<1.30, 1.30-3.49, ≥3.50), smoking status (never smoker, former smoker, current smoker), alcohol use (none, moderate, heavy), and sleep duration (<7h, 7-9h, ≥9h). Body mass index (kg/m^2) was calculated as weight (kg) divided square of height (m^2), both of which were directly measured during physical examination. Leisure-time physical activity was assessed using the Global Physical Activity Questionnaire, which was converted to metabolic equivalents (minutes/week, METs) and categorized as ≥600 vs. <600 METs. Total energy intake (kcal/day) was derived from 24-h dietary recalls.

2.4. Accelerated Biological Aging (ABA) measurement

We calculated biological age using PhenoAge algorithm based on 12 biomarkers (i.e., albumin, alkaline phosphatase, blood urea nitrogen, C-reactive protein, creatinine, glycated hemoglobin, mean cell volume, lymphocyte percentage, systolic blood pressure, total cholesterol, uric acid, and white blood cell count) via the "BioAge" R package [19]. ABA was defined as present if the residual difference between biological age and chronological age was positive.

In addition, information on covariates, including age, sex, race/ethnicity, education, poverty-income-ratio, marital status, smoking status, alcohol drinking, leisure-time physical activity, body mass index (BMI), total energy intake, and sleep duration, was also collected (see footnote 2 under Table 1 for details).

2.5. Statistical analysis

Statistical tests were performed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA) and R (version 4.2.2).

Statistical differences in characteristics between ED and SW groups were compared using Analysis of Variance for continuous variables and Chi-square test for categorical variables.

We first explored the relationship between ED and ABA by plotting the raw prevalence of ABA by ED hourly increment and then categorized ED as <12 h (short eating duration: SED), 12−14 h (moderate eating duration: MED; reference), and ≥14 h (long eating duration: LED) in primary analysis to maintain sufficient sample size in each category.

We used weighted Poisson regression with robust variance estimation, adjusting for covariates, to examine the independent and joint associations. ED and SW were mutually adjusted for independent associations. For joint associations, we created 6 combinations for ED and SW categories: (1) MED + NSW (reference), (2) SED + NSW, (3) LED + NSW, (4) MED + SW, (5) SED + SW, (6) LED + SW. To further explore whether the relationship of ED and SW with ABA varied by participants characteristics, we performed subgroups analyses by adding an interaction term and then conducting stratified analyses. We imputed missing values as a missing category for categorical variables and median for continuous variables.

We conducted two sensitivity analyses regarding ED: (1) excluding participants with extreme ED (i.e., <6 h or >21 h), and (2) stratifying by early vs. late first meal at 8 AM (median). We performed two sensitivity analyses regarding SW: (1) categorizing work schedule into 4 groups: evening or night, early morning, rotating, and daytime work (reference), and (2) including participants working on "another schedule" (N = 654). Four additional sensitivity analyses were conducted for both ED and SW analyses, including using multiple imputation for missing covariates, excluding people with prevalent cardiovascular diseases or cancer, calculating biological age using Klemera-Doubal methods, and examined associations with 12 biological age biomarkers individually.

3. Results

3.1. Participant characteristics

Compared to the MED group (12–14 h), SED group (<12 h) was more likely to be younger, male, non-Hispanic Black, unmarried, current smokers, have unhealthy sleep, lower income, lower education, and lower energy intake (Table 1). LED group (≥14 h) was more likely to be older, male, non-Hispanic White, widowed/divorced/separated, current smokers, have higher income, higher energy intake, lower education, and shorter sleep. Compared to NSW, people with SW were more likely to be younger, non-Hispanic Black, unmarried, current smokers, drinkers, have lower income, lower education, longer sleep, and higher BMI.

3.2. Association between ED and ABA

The relationship between ED and crude ABA prevalence was non-linear, with the lowest prevalence at 13−14 h (Figure S2). In the crude model, there was a U-shaped association that both SED (<12 h; PR, 1.22; 95%CI, 1.08–1.37) and LED (≥14 h; PR, 1.19; 95%CI, 1.05–1.34) were associated with elevated prevalences of ABA compared to MED group (12−14 h) (Table 2). After adjusting for covariates, the U-shaped relationship persisted (SED: PR, 1.13; 95%CI, 1.01–1.27; LED: PR, 1.07; 95%CI, 0.96–1.19) but was slightly attenuated for LED with more uncertainty.

Results remained consistent in most sensitivity analyses (Table S1). The U-shaped association of ED and ABA remained among individuals who started eating window later than 8 AM (SED: PR, 1.16; 95%CI, 1.01–1.33; LED: PR, 1.21; 95%CI, 1.02–1.42) but not among those started eating window before 8 AM (SED: PR, 1.02; 95%CI, 0.79–1.31; LED: PR, 1.02; 95%CI, 0.88–1.20; as compared to MED) (Table S2). When we examined individual component of ABA, SED was associated with albumin and alkaline phosphatase, while LED was associated with total cholesterol (Table S3).

3.3. Association between SW and ABA

SW was associated with a higher prevalence of ABA compared to NSW in both crude (PR, 1.21; 95%CI, 1.09–1.33) and adjusted models (PR, 1.10; 95%CI, 1.01–1.20) (Table 2).

Results remained consistent in sensitivity analyses (Table S4). SW was associated with changes in albumin, alkaline phosphatase, blood urea nitrogen, lymphocyte percent, mean cell volume, and total cholesterol (Table S3). Rotating shift work was significantly associated with a higher prevalence of ABA (PR, 1.14; 95%CI, 1.01–1.28) (Table S5). Individuals working on "another schedule" did not have significantly different prevalence of ABA compared to NSW (PR, 1.08; 95%CI, 0.90–1.30).

3.4. Joint associations of ED and SW with ABA

People with SW had a slightly longer ED (mean (SE): 13.12 (0.05)) than those with NSW (mean (SE): 13.05 (0.09)). The highest ABA prevalence was observed in SED + SW group (e: PR, 1.19; 95%CI, 1.02–1.40) compared to MED + NSW group (a: reference) (Fig. 1), followed by LED + SW group (f). Results were robust in four sensitivity analyses (Table S6).

Table 2
Independent associations of eating duration and work schedule with accelerated biological aging.

	Eating duration[2]			Work schedule	
	<12 h (SED)	12–14 h (MED)	≥14 h (LED)	NSW	SW
	PR (95%CI)			PR (95%CI)	
No. Events / Total	902/3,336	1,198/5,070	523/1,805	1,707/6,872	931/3,190
Crude Model	1.22 (1.08, 1.37)*	1.00 (REF)	1.19 (1.05, 1.34)*	1.00 (REF)	1.21 (1.09, 1.33)*
Adjusted Model[1]	1.13 (1.01, 1.27)*	1.00 (REF)	1.07 (0.96, 1.19)	1.00 (REF)	1.10 (1.01, 1.20)*

Abbreviations: LED, long eating duration; MED, moderate eating duration; SED, short eating duration; SW, shift work; NSW, non-shift work.

* p-value<0.05.

[1] Model adjusted for age, sex, race/ethnicity, education, poverty-income-ratio, marital status, smoking status, alcohol drinking, physical activity, body mass index, total energy intake, and sleep duration. Eating duration and shift work were mutually adjusted.

[2] Eating duration: short (<12 h), moderate (12-14 h), long (≥14 h).

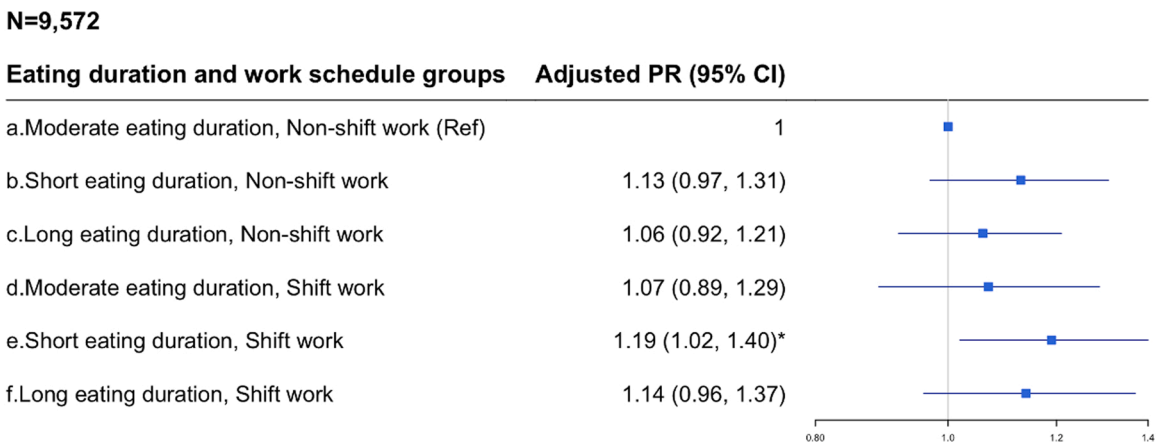

Fig. 1. Joint associations of eating duration and work schedule with accelerated biological aging. The model adjusted for age, sex, race/ethnicity, education, poverty-income-ratio, marital status, smoking status, alcohol drinking, physical activity, body mass index, total energy intake, and sleep duration. Eating duration: short (<12 h), moderate (12–14 h), and long (≥14 h).

3.5. Subgroup analysis

Although no statistically significant interactions were detected in the individual associations of ED or SW with ABA by subgroups, stratified analyses indicated that SED was particularly associated with a higher prevalence of ABA among participants who were White, low-income, never smokers, alcohol drinkers, physically active, and slept ≥9 h, while LED was only significantly associated with ABA among low-income participants (Figure S3(A)). SW was particularly associated with a higher prevalence of ABA among participants who were older, high-income, college-educated, married or living with partner, never smokers, slept for 7−9 h, and had lower energy intake (Figure S3(B)). Additionally, physical activity significantly modified the joint associations of ED and SW (p-for-interaction = 0.01). Experiencing both SW and SED was associated with higher ABA prevalence among physically actively participants, whereas experiencing LED or MED with SW was associated with higher ABA prevalence among physically inactive participants (Table S7).

4. Discussion

Our results suggested a U-shaped relationship between ED and ABA, with a stronger association for SED. Compared to individuals with MED (12−14 h), those with SED (<12 h) and LED (≥14 h) had a 13% and a suggestive 7% increase in ABA prevalence, respectively. Moreover, this U-shaped association was more obvious among individuals initiated first meal later than 8 AM. Meanwhile, SW was associated with a 10% higher prevalence of ABA. Notably, workers with both SED and SW had a 19% increased prevalence of ABA, where ED (particularly SED) appeared to determine ABA prevalence compared to SW.

Current evidence suggested similar results that SW was associated with accelerated aging among UK cohorts [10,11,13] and U.S. non-Hispanic White women [12]. We further demonstrated that SW could influence liver, kidney, immune system, and lipid profile, which has been suggested for SW exposure [20,21].

A meta-analysis of interventional studies indicated that shorter eating window (within 6−10 h) is beneficial for cardiometabolic health [22], but these interventions were short in duration (<48 weeks). No interventional studies have directly examined the effect of SED on aging or its biomarkers. We found only one observational study that investigated the association of night fasting duration with biological aging, suggesting that both SED and LED were positively associated with ABA among general U.S. adults [9]. Two studies in U.S. adult population also suggested a U-shaped relationship between ED and mortality risk [23, 24].

Our results in U.S. working population were consistent with above studies. In addition, our findings indicated that the effect of ED may be related to first meal timing. When stratified by first meal timing before or after 8 AM, we found that the detrimental effect of both SED and LED manifested when the eating window was initiated late. Delayed eating can compound circadian rhythm through hormonal disruption and metabolic stress [25]. Both experimental and observational studies suggested that an early short eating window was more beneficial for metabolic outcomes than a delayed one [26,27], but evidence on aging is lacking. We only found a recent study reporting later breakfast timing was associated with an increased mortality risk [28].

The detrimental effect of SED on biological aging is plausible and may directly relate to extended fasting. A recent animal study revealed that improving metabolic traits after long fasting (i.e., short ED) may not necessarily translate into lifespan extension [29]. One possible explanation could be the loss of lean mass after extended fasting, which is a risk factor for ABA [30].

Our study has high generalizability for general U.S. working population and low likelihood of residual confounding. Notably, ED was calculated by only two dietary recalls and may not capture habitual eating behaviors. However, even measurement errors for ED exist, they are likely to be nondifferential because participants were unaware of their biological aging status at the time of dietary recalls. Other limitations include the lack of data on sleep timing and the inability to distinguish workers on night shift. Finally, due to the cross-sectional design, we cannot rule out reverse causality. Large longitudinal studies with ED measurement in relation to internal circadian time are warranted.

5. Conclusion

Eating duration and shift work were independently and jointly associated with a higher prevalence of accelerated biological aging among U.S. workers. Employers may consider adopting more stable shifts and providing flexible meal breaks, while workers, particularly those with shift working schedules, could limit both extended nighttime fasting and prolonged eating window.

CRediT authorship contribution statement

Conceptualization, Ren X, Li J, and Chen L; Methodology, Ren X, Li J, and Chen L; Software, Ren X; Formal Analysis, Ren X; Visualization, Ren X; Supervision, Li J and Chen L; Writing- Original draft preparation, Ren X, Li J, and Chen L; Writing – review & editing, Ren X, Li J, and Chen L; Funding Acquisition, Ren X, Li J, and Chen L. All authors have read and

agreed to the published version of the manuscript.

Declaration of Generative AI and AI-assisted technologies in the writing process

No Generative AI or AI-assisted technologies were used in the writing process.

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Availability of data and material

NHANES Data described in the manuscript is publicly and freely available without restriction at https://wwwn.cdc.gov/nchs/nhanes/.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

[1] Data and Statistics on Aging Workers. [cited 2024; Available from: https://www.cdc.gov/niosh/aging/data-research/index.html.
[2] Labor Force Statistics from the Current Population Survey, 2021 Annual Averages. [cited 2024; Available from: https://www.bls.gov/cps/cps_aa2021.htm.
[3] Liu Z, Kuo P-L, Horvath S, Crimmins E, Ferrucci L, Levine M. A new aging measure captures morbidity and mortality risk across diverse subpopulations from NHANES IV: a cohort study. PLoS Med 2018;15(12):e1002718.
[4] Flynn JM, O'Leary MN, Zambataro CA, Academia EC, Presley MP, Garrett BJ, et al. Late-life rapamycin treatment reverses age-related heart dysfunction. Aging cell 2013;12(5):851–62.
[5] Jia J, Wen CP, Tu H, Pan J, Lu W, Yang M, et al. Lifestyles modify the biological aging process: evidence from multiple cohorts. Am J Epidemiol 2025.
[6] Ali M, Reutrakul S, Petersen G, Knutson KL. Associations between timing and duration of eating and glucose metabolism: a nationally representative study in the U.S. Nutrients 2023;15(3).
[7] Atwater AQ, Immergluck LC, Davidson AJ, Castanon-Cervantes O. Shift work predicts increases in lipopolysaccharide-binding protein, interleukin-10, and leukocyte counts in a cross-sectional study of healthy volunteers carrying low-grade systemic inflammation. Int J Environ Res Public Health 2021;18(24).
[8] Makarem N, Sears DD, St-Onge MP, Zuraikat FM, Gallo LC, Talavera GA, et al. Habitual nightly fasting duration, eating timing, and eating frequency are associated with cardiometabolic risk in women. Nutrients 2020;12(10).
[9] Wang X, Zhang J, Xu X, Pan S, Cheng L, Dang K, et al. Associations of daily eating frequency and nighttime fasting duration with biological aging in National Health and Nutrition Examination Survey (NHANES) 2003–2010 and 2015–2018. Int J Behav Nut Phys Activity 2024;21(1):104.
[10] Wang J-N, Hu W, Liu B-P, Jia C-X. Associations between shift work and biological age acceleration: a population-based study. GeroScience 2025.
[11] Shen W, Cai L, Li J, Sun Y, Wang B, Wang N, et al. Association of night shift work and biological ageing: the mediating role of body mass index. Age Ageing 2024;53(11).
[12] White AJ, Kresovich JK, Xu Z, Sandler DP, Taylor JA. Shift work, DNA methylation and epigenetic age. Int J Epidemiol 2019;48(5):1536–44.
[13] Freni-Sterrantino A, Fiorito G, d'Errico A, Virtanen M, Ala-Mursula L, Järvelin MR, et al. Association between work characteristics and epigenetic age acceleration: cross-sectional results from UK - Understanding Society study. Aging (Albany NY) 2022;14(19):7752–73.
[14] Terada T, Mistura M, Tulloch H, Pipe A, Reed J. Dietary Behaviour Is Associated with Cardiometabolic and Psychological Risk Indicators in Female Hospital Nurses-A Post-Hoc, Cross-Sectional Study. Nutrients 2019;11(9).
[15] National Health and Nutrition Examinations Survey Data. National Center for Health Statistics.
[16] Raper N, Perloff B, Ingwersen L, Steinfeldt L, Anand J. An overview of USDA's dietary intake data system. J Food Compos Anal 2004;17(3–4):545–55.
[17] Ansu Baidoo VY, Zee PC, Knutson KL. Racial and ethnic differences in eating duration and meal timing: findings from NHANES 2011–2018. Nutrients 2022;14(12):2428.
[18] Storz MA, Rizzo G, Lombardo M. Shiftwork is associated with higher food insecurity in U.S. workers: findings from a cross-sectional study (NHANES). Int J Environ Res Public Health 2022;19(5).
[19] Kwon D, Belsky DW. A toolkit for quantification of biological age from blood chemistry and organ function test data: BioAge. GeroScience 2021;43(6):2795–808.
[20] Zhao Y, Lu X, Wang Y, Cheng Y, He Q, Qin R, et al. Peripheral blood lipid and liver and kidney function test results in long-term night shift nurses: a cross-sectional study in South China. Front Endocrinol (Lausanne) 2023;14:1237467.
[21] Loef B, Nanlohy NM, Jacobi RHJ, van de Ven C, Mariman R, van der Beek AJ, et al. Immunological effects of shift work in healthcare workers. Sci Rep 2019;9(1):18220.
[22] Liang X, Chen J, An X, Ren Y, Liu Q, Huang L, et al. The optimal time restricted eating interventions for blood pressure, weight, fat mass, glucose, and lipids: a meta-analysis and systematic review. Trends Cardiovasc Med 2024;34(6):389–401.
[23] Cheng W, Meng X, Gao J, Jiang W, Sun X, Li Y, et al. Relationship between circadian eating behavior (daily eating frequency and nighttime fasting duration) and cardiovascular mortality. Int J Behav Nut Phys Activity 2024;21(1):22.
[24] Li M, Huang J, Du S, Sun K, Chen J, Guo F. Long-term effect of eating duration on all-cause mortality under different energy intake and physical activity levels. Br J Nutr 2024;132(11):1513–21.
[25] Alum EU. Circadian nutrition and obesity: timing as a nutritional strategy. J Health Popul Nutr 2025;44(1):367.
[26] Palomar-Cros A, Srour B, Andreeva VA, Fezeu LK, Bellicha A, Kesse-Guyot E, et al. Associations of meal timing, number of eating occasions and night-time fasting duration with incidence of type 2 diabetes in the NutriNet-Santé cohort. Int J Epidemiol 2023;52(5):1486–97.
[27] Liu J, Yi P, Liu F. The effect of early time-restricted eating vs later time-restricted eating on weight loss and metabolic health. J Clin Endocrinol Metab 2023;108(7):1824–34.
[28] Dashti HS, Liu C, Deng H, Sharma A, Payton A, Maharani A, et al. Meal timing trajectories in older adults and their associations with morbidity, genetic profiles, and mortality. Commun Med 2025;5(1):385.
[29] Di Francesco A, Deighan AG, Litichevskiy L, Chen Z, Luciano A, Robinson L, et al. Dietary restriction impacts health and lifespan of genetically diverse mice. Nature 2024;634(8034):684–92.
[30] Xie Y, Zhou K, Shang Z, Bao D, Zhou J. The effects of time-restricted eating on fat loss in adults with overweight and obese depend upon the eating window and intervention strategies: a systematic review and meta-analysis. Nutrients 2024;16(19).