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Association between yoga and multimorbidity: a nationwide study of 279,885 middle-aged and older adults

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Abstract

Background The health benefits of exercise have been well-established, but the specific role of yoga in multimorbidity was less understood. This study aimed to examine the association between yoga and multimorbidity in comparison with other exercises or non-exercise.

Methods This cross-sectional study pooled nationally representative surveys from Behavioral Risk Factor Surveillance System (BRFSS) (2015, 2017, and 2019), and classified 279,885 participants aged 45 + years as yoga practitioners, other exercisers, and non-exercisers. Multinominal and binary logistic regressions were separately used for association of yoga with multimorbidity (coexistence of ≥ 2 conditions) and individual chronic conditions. Potential effect modification by age, sex, education level, and race/ethnicity was examined. We further assessed the dose-response association of duration and frequency of yoga practice with multimorbidity.

Results The adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for yoga practitioners ($n = 5081$) vs. other exercisers ($n = 192,718$) were 0.69 (95% CI 0.55–0.86) for coexistence of two conditions, and 0.72 (95%CI 0.58–0.89) for coexistence of ≥ 3 conditions. The associations were stronger (ORs ranged from 0.43 to 0.52; $P < 0.0001$ for all) when comparing yoga practitioners with non-exercisers ($n = 82,086$), which were more pronounced in women relative to men (P-interaction < 0.05). Increased duration or frequency of yoga practice was associated with lower odds of multimorbidity in a dose-response manner (P for trend<0.0001 for all). Similar inverse associations were observed between yoga and individual chronic conditions.

Conclusion Yoga was associated with lower odds of multimorbidity in middle-aged and older adults, relative to other exercises or non-exercise.

Keywords Yoga, Multimorbidity, Chronic conditions, Dose-response association

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Background

Yoga is a mind-body practice, which may benefit physical function through increasing the relaxation, flexibility, and strength of muscle [1, 2]. Most existing studies focus on the role of yoga-related exercises in specific diseases, such as mental health and diabetes [3, 4]. Several interventional studies suggested yoga may improve cardiometabolic health [5], cognitive function [6], and depressive disorders [7]. However, these studies were limited by the relatively small sample size, lower generalizability, and short follow-up, and consequently few large-scale studies investigate the role of yoga on the overall health. In comparison with other exercises, there were potential benefits of yoga on strength and flexibility of lower body, ameliorating depression, and glycemic control [8, 9]. It is not clear whether yoga might provide additional health benefits than other exercises regarding overall health. Additionally, identifying the subpopulations that could benefit the most from yoga also warrants in-depth exploration.

Therefore, incorporating the definition of multimorbidity as the presence of two or more conditions [10], we leveraged a nationally representative sample of ~280,000 participants in the United States (US) to examine the cross-sectional association of yoga with multimorbidity and individual chronic conditions, with other exercises or non-exercise as the reference group. Subgroup analyses were conducted to examine potential effect modification by age, sex, education level, and race/ethnicity. Further, we investigated whether the duration and frequency of yoga practice was associated with the outcomes.

Methods

Study design and participants

The Behavioral Risk Factor Surveillance System (BRFSS) is a US national cross-sectional survey conducted collaboratively by the Centers for Disease Control and Prevention (CDC) and participating states and territories [11]. The annual survey collects information on health-related behaviors, chronic conditions, and use of preventive services using the core component, optional modules, and state-added questions. Additionally, the BRFSS data underwent a validation process to confirm its reliability [12].

Initially included were 508,202 participants aged 45 + years (from 32 states in 2015, 10 states in 2017, and 35 states in 2019) who responded to questionnaires on exercise type (core component) and cognitive function (optional modules). The final study population included 279,885 eligible participants, after excluding 228,317 participants with incomplete data on exercise types, chronic conditions (i.e. obesity, diabetes, hyperlipidemia, hypertension, coronary artery disease [CAD], stroke, subjective cognitive decline [SCD], and SCD-related functional limitations), and potential mediator (i.e. depressive status). This study utilized de-identified data from a publicly available dataset that was exempt from Institutional Review Board approval.

Exposure

Exercisers were the participants who engaged in any physical activity during the past month (yes/no), and non-exercisers were those who reported no participation in any physical activity. The exercisers were further asked to choose their top two types of exercises based on the question "What type of physical activity or exercise did you spend the most/next most time doing during the past month?". Exercisers who chose yoga as one of the top two exercises (from the more than 70 exercises listed by the BRFSS) were defined as yoga practitioners, and the rest exercisers were considered as other exercisers. They then reported the corresponding frequency and duration of each exercise on a weekly or monthly basis, according to "How many times per week or per month did you take part in this activity?", and "And when you took part in this activity, for how many minutes or hours did you usually keep at it?". Yoga practitioners were further divided into ordered groups based on duration (1–59, 60–119, and ≥ 120 min/week) or frequency (0.1-1, 1.1-2, and ≥ 2 times/week), allowing for a dose-response analysis.

Health-related outcomes

The primary outcome multimorbidity was defined as the coexistence of two or more chronic conditions, including obesity, diabetes, hyperlipidemia, hypertension, CAD, stroke, SCD, SCD-related functional limitations. The number of conditions was summed to define the extent of multimorbidity, which was classified as (1) condition-free (the reference group), (2) existence of one condition, (3) coexistence of two conditions, and (4) coexistence of ≥ 3 conditions.

The secondary outcomes were the eight chronic conditions. The BRFSS defined obesity as having a BMI of 30.0 kg/m^2 or greater, calculated as individual weight (kg) divided by height squared (m^2). The straightforward yes-or-no question ("Has a doctor, nurse, or other health professional ever told you that you had any of the following?") were used to assess whether the participants ever had other cardiometabolic conditions, including diabetes, hyperlipidemia, hypertension, CAD (i.e. heart attack or coronary heart disease), and stroke. The SCD was identified as experiencing confusion or memory loss more frequently during the past 12 months (yes/no). If the participants with SCD reported "Always" or "Usually" or "Sometimes" having difficulty with household activities or social activities due to SCD, they were considered to have SCD-related functional limitations [13].

Potential covariates and mediators

Data on demographic characteristics (age, sex, race, marital status, and BMI), socioeconomic status (education level and annual household income), and lifestyle factors (smoking status and drinking status) were self-reported. Participants who smoked ≥ 100 cigarettes in their lifetime or were currently smoking were classified as current smokers. Participants who drank ≥ 1 alcoholic beverage in the past 30 days were categorized as current drinkers. Notably, the adjustment for energy expenditure (MET-hours/week) in the subsequent multivariable analyses aimed to control the confounding effect from other exercise performed by yoga practitioners, which equaled to the product of BRFSS-assigned metabolic equivalent task (MET) values of each exercise and its corresponding exercise duration (hours/week) [14, 15]. The compendium of physical activity from the BRFSS [16] assigned yoga a MET value of 0. Among these covariates, missing values were imputed with the median for continuous variables and classified as a separate group for categorical variables.

In terms of the potential mediator, depressive status was assessed through a question "Has a doctor, nurse, or other health professional ever told you had a depressive disorder (including depression, major depression, dysthymia, or minor depression)?".

Statistical analysis

We initially calculated characteristics of the study population according to exercise types. To estimate the statistics and variance properly in BRFSS, our analyses incorporated weighting, stratification, and clustering of the complex sampling scheme [11]. To assess the association between exercise types and the multiple categorical outcome (i.e. number of conditions), we constructed multinominal logistic regression models. When examining the association for the binary outcome (i.e. individual conditions), binary logistic regression was adopted. Comparisons were made using either other exercise or non-exercise as the reference. The adjusted odds ratio (OR) and 95% confidence interval (CI) were used to present the results. Subgroup analyses for association between yoga and multimorbidity were conducted according to potential effect modifiers: age, sex, education level, and race/ethnicity using the mentioned multinominal logistic regression models. Likelihood ratio test was adopted to assess potential interaction between yoga and effect modifiers; and Bonferroni correction was considered when interpreting the results.

The association between duration and frequency of yoga practice and multimorbidity were similarly examined as mentioned above. The *P* values for linear trend were calculated by modeling the duration and frequency of yoga practice as an ordinal variable. Further assessment was the extent to which depressive status potentially mediated the potential associations using a SAS macro MEDIATE% [17].

Two sensitivity analyses were performed. First, to further control for other energy expenditure from yoga practitioners, we conducted a sensitivity analysis in which yoga practitioners who engaged in other exercises for 150 + minutes/week were excluded, following the recommendation for health benefits from aerobic guidelines of Physical Activity Guideline for Americans (2nd edition) [18]. Second, to examine the model robustness, the multinominal logistic regression model without the incorporation of weighting, stratification, and clustering was used to examine the association between yoga and multimorbidity.

All data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, NC) and R version 4.2 (R Foundation for Statistical Computing, Vienna, Austria). We considered two-sided $P<0.05$ to be statistically significant.

Results

Table 1 showed the characteristics of the 279,885 study participants. Among them, yoga practitioners ($n = 5081$) were more likely to be younger, women, non-Hispanic White, married individuals, and tended to have higher education or income, compared with other exercisers ($n = 192,718$) and non-exercisers ($n = 82,086$) (Table 1). The BMI and prevalence of current smoking were lower in yoga practitioners while prevalence of current drinking was higher.

Overall, the non-adjusted prevalence of multimorbidity (≥ 2 conditions; 35.8%) in yoga practitioners was lower than other exercisers and non-exercisers (Table 1; Fig. 1). The multivariable adjusted ORs for yoga practitioners vs. other exercisers were 0.69 (95%CI 0.55–0.86) for coexistence of two conditions, and 0.72 (95%CI 0.58–0.89) for coexistence of 3 + conditions (Fig. 1). When using non-exercisers as a reference group, the associations between yoga and multimorbidity (coexistence of two conditions: OR 0.52, 95%CI 0.41–0.65; coexistence of 3 + conditions: OR 0.43, 95%CI 0.34–0.53) were stronger. Additionally, as the number of coexisting conditions increased, the associations became stronger (*P* for trend<0.0001 for all).

Similarly, all individual conditions were less prevalent among yoga practitioners than in other exercisers and non-exercisers (Fig. 2). The inverse associations of yoga with obesity (OR 0.42, 95%CI 0.35–0.50), diabetes (OR 0.63, 95%CI 0.49–0.81), hyperlipidemia (OR 0.84, 95%CI 0.74–0.96), and hypertension (OR 0.77, 95%CI 0.66–0.90) remained significant in full models, compared with other exercises.

Interaction between yoga and sex was statistically significant for multimorbidity using non-exercisers as the reference (Fig. 3). Subgroup analyses showed a significant

Table 1 Characteristics of non-exercisers, yoga practitioners, and other exercisers ($n = 279,885$)

	Non-exercisers	Yoga practitioners	Other exercisers
Respondents, %	82,086 (29.3)	5081 (1.8)	192,718 (68.9)
Age, years, %			
< 60	25,371 (41.6)	2071 (54.0)	66,526 (45.1)
60-69.9	24,170 (27.6)	1745 (28.7)	61,917 (29.1)
70-79.9	19,736 (19.1)	927 (12.9)	43,735 (17.8)
≥ 80	12,451 (11.1)	311 (4.0)	19,486 (7.3)
Missing	358 (0.6)	27 (0.4)	1054 (0.8)
Sex, women, %	49,674 (55.9)	4336 (82.1)	106,266 (50.3)
Ethnicity, Non-Hispanic Whites, %	61,141 (66.2)	4312 (75.3)	155,266 (72.3)
Married status, in a relationship, %	40,393 (55.1)	3132 (69.4)	115,959 (65.4)
Education, %			
Not graduate from high school	9964 (19.7)	52 (2.9)	10,057 (9.5)
Graduated from high school	29,731 (34.8)	550 (14.4)	46,324 (24.9)
Attended college or technical school	22,872 (28.5)	1155 (25.7)	52,074 (30.6)
Graduated from college or technical school	19,336 (16.7)	3316 (56.9)	83,988 (34.8)
Missing	183 (0.3)	8 (0.1)	275 (0.2)
Annual household income, %			
<$15,000	10,728 (13.2)	170 (3.0)	12,338 (6.5)
$15,000–49,999	34,874 (41.5)	1212 (20.4)	61,991 (30.6)
≥$50,000	23,081 (30.1)	2999 (63.7)	92,016 (50.1)
Missing	13,403 (15.2)	700 (12.9)	26,373 (12.8)
Body mass index (BMI), kg/m^2, SE	29.9 ± 0.05	25.5 ± 0.14	28.1 ± 0.03
Current smoker, %	14,575 (19.6)	331 (6.5)	20,318 (11.7)
Current drinker, %	28,694 (37.6)	3377 (64.9)	100,265 (53.9)
Energy expenditure, MET-hours/week, SE	0.0	13.4 ± 0.58	26.2 ± 0.19
Depression, %	20,230 (24.6)	992 (16.9)	31,119 (15.4)
Multimorbidity, %	54,147 (64.2)	1443 (35.8)	94,724 (47.8)

Data were summarized as unweighted counts and weighted proportions for categorical variables and weighted mean ± standard error (SE) for continuous variables

inverse association between yoga and number of conditions in women, but not in men. We observed similar inverse yoga-multimorbidity associations in subgroups defined by age, education level, and race/ethnicity (P-interaction > 0.05; Fig. 3).

Participants with higher duration (≥ 60 min/week) or frequency (≥ 1 times/week) of yoga had lower likelihood of multimorbidity (P for trend<0.0001 for all; Supplemental Table 1). Mediation analysis showed that depressive status partially explained the association of yoga with SCD (9.2%) and multimorbidity (2.5%) (Supplemental Table 2). Our findings persisted, when excluding a portion of the yoga practitioners who engaged in other exercises for ≥ 150 min/week, or using models without the incorporation of weighting, stratification, and clustering (Supplemental Table 3).

Discussion

In this large-scale, nationwide study, yoga practitioners had a lower likelihood of multimorbidity than non-exercisers and other exercisers. The observed associations for yoga vs. non-exercise were more pronounced in women relative to men. Increased duration or frequency of yoga practice was associated with lower odds of multimorbidity. In addition, similar patterns persisted for several individual conditions, including obesity, diabetes, hyperlipidemia, and hypertension.

Our findings suggested that yoga was associated with a ~ 30% lower likelihood of multimorbidity, compared with other exercises, which was even stronger when compared with non-exercise. To the best of our knowledge, the role of yoga against multimorbidity had not been previously studied, especially in comparison with other forms of exercise. Nonetheless, our findings are generally consistent with prior findings on yoga and individual cardiometabolic diseases or mental conditions [19, 20], which may also support the inverse yoga-multimorbidity association. For example, evidence from HABITAT cohort showed yoga/ta chi practitioners may have a lower likelihood of obesity (OR 0.77, 95%CI 0.62–0.95), diabetes (OR 0.75, 95%CI 0.52–1.09), and hypertension (OR 0.87, 95%CI 0.72–1.05) [19]. Additionally, yoga may confer additional benefits beyond aerobic exercise in improving verbal acquisition and attention [20], which are important components in evaluating cognitive function [21, 22]. Noteworthily, similar associations of yoga with obesity, diabetes, hyperlipidemia, and hypertension were also observed in this study when compared with other exercises.

Interestingly, our findings suggested that the role of yoga in multimorbidity may differ between men and women. The more pronounced inverse association in women was generally consistent with another BRFSS-based study, in which muscle-strengthening activity (MSA, defining yoga practice as one of assessment criteria) was associated lower odds of hypertension in

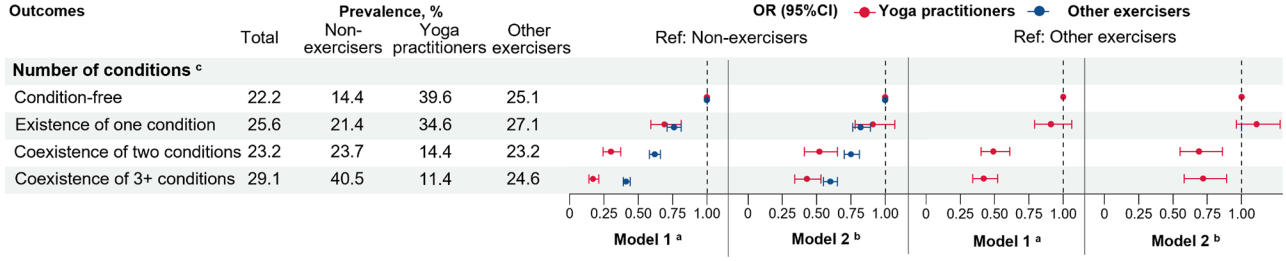

Fig. 1 Association between exercise types and multimorbidity ($n = 279{,}885$). (**a**) Model 1: Adjusted for age (< 60, 60-69.9, 70-79.9, ≥ 80 years old), sex (men, women), education level (not graduate from high school, graduated from high school, attended college or technical school, graduated from college or technical school, missing), race/ethnicity (non-Hispanic White, other, missing). (**b**) Model 2: Additionally adjusted for marital status (married or living as married, other, missing), annual household income (<$15000, $15000–49999, ≥$50000, missing), body mass index (kg/m^2), current smoker (yes, no, missing), current drinker (yes, no, missing), energy expenditure (MET-hours/week). (**c**) To assess the severity of multimorbidity, we calculated the number of coexisting conditions for the participants as the outcome and categorized those who devoid of conditions as the reference group. Number of conditions: *P* for trend<0.0001 for all

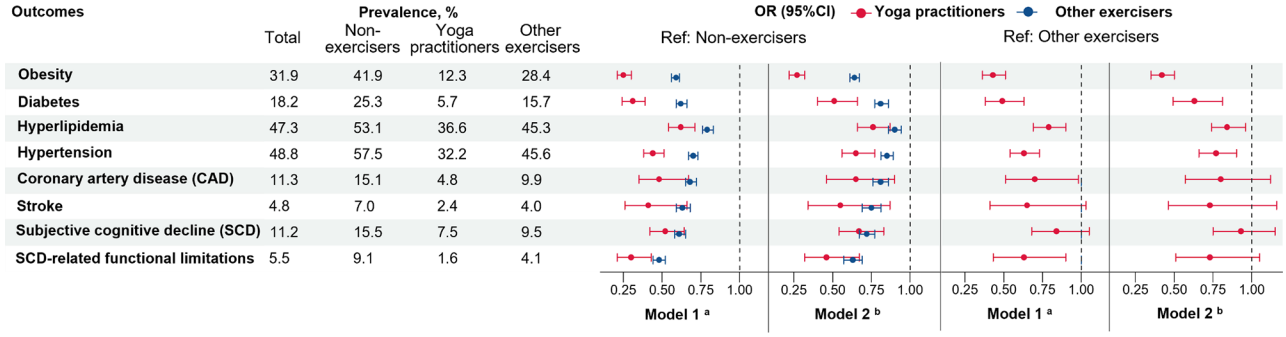

Fig. 2 Association between exercise types and individual chronic conditions ($n = 279{,}885$). (**a**) Model 1: Adjusted for age (< 60, 60-69.9, 70-79.9, ≥ 80 years old), sex (men, women), education level (not graduate from high school, graduated from high school, attended college or technical school, graduated from college or technical school, missing), race/ethnicity (non-Hispanic White, other, missing). (**b**) Model 2: Additionally adjusted for marital status (married or living as married, other, missing), annual household income (<$15000, $15000–49999, ≥$50000, missing), body mass index (kg/m^2), current smoker (yes, no, missing), current drinker (yes, no, missing), energy expenditure (MET-hours/week). Obesity: not adjusted for body mass index (kg/m^2) in model 2

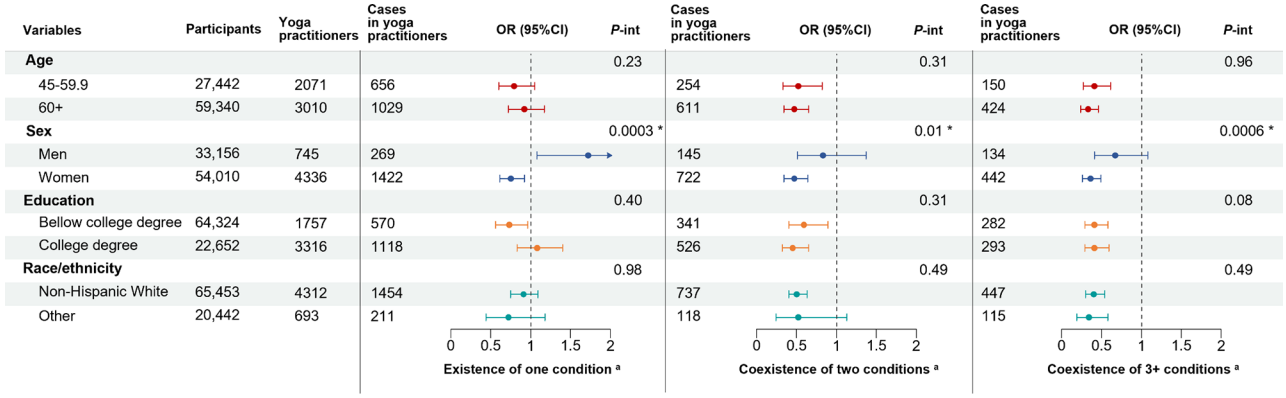

Fig. 3 Multiplicative interaction and subgroup analyses for association between yoga and multimorbidity (yoga practitioners vs. non-exercisers). Adjusted for age (< 60, 60-69.9, 70-79.9, ≥ 80 years old), sex (men, women), education level (not graduate from high school, graduated from high school, attended college or technical school, graduated from college or technical school, missing), race/ethnicity (non-Hispanic White, other, missing), marital status (married or living as married, other, missing), annual household income (<$15000, $15000–49999, ≥$50000, missing), body mass index (kg/m^2), current smoker (yes, no, missing), current drinker (yes, no, missing), energy expenditure (MET-hours/week). (**a**) To assess the severity of multimorbidity, we calculated the number of coexisting conditions for the participants as the outcome and categorized those who devoid of conditions as the reference group. **P*-int: *P* for interaction remained significant after multiple testing with Bonferroni correction

women [23]. One potential reason is that middle-aged women may seek to alleviate their menopausal symptoms through yoga [24]. Although yoga was more popular among women than men [25, 26], men may begin their medically mandated yoga practice under supervision, because yoga showed potential as a complementary therapy for managing metabolic syndrome or depression [7, 27]. Given that many existing yoga-related studies had limited number of men [3, 28–30], we cannot rule out the possibility that yoga may be beneficial in men [7].

We demonstrated an inverse dose-response association of duration or frequency of yoga practice with multimorbidity, and several chronic conditions. More specifically, practicing yoga for ≥ 60 min/week or ≥ 1 times/week was associated with the lower odds of multimorbidity. Given that yoga was incorporated as one of the definition criteria for MSA in several studies [3, 23, 31], our findings were consistent with the US physical activity guidelines in which engaging in MSA for ≥ 2 times/week was recommend to gain the substantial health benefits [32]. Therefore, our results suggested that practicing yoga for at least one hour or one time per week may provide sufficient health benefit, further underscoring the potential of yoga as a time-efficient and effective strategy for improving overall health and managing chronic conditions.

Major strength of this study was the large and nationally representative sample. Although yoga has become increasingly popular, it is relatively less common compared with other forms of physical activity. The large sample size allowed us to investigate yoga with sufficient statistical power. In addition to multimorbidity, we conducted an extensive analysis of individual chronic conditions to understand the role of yoga in health. Our comparisons with two types of reference (other exercises and no exercise) demonstrated the robustness of the findings.

There also existed several limitations. First, this study was based on cross-sectional data, which does not allow for causal interpretations. Although we observed a potential dose-response associations between frequency and duration of yoga and outcomes, the associations could be bidirectional. Second, yoga practitioners were defined based on the top two exercises reported by participants, which might be subject to misclassification bias. It is likely the health benefits associated with yoga may be confounded by other forms of exercises. We attempted to address this by adjusting for energy expenditure in the main analysis. Given the potential concern regarding the validity of using MET-hours/week for assessing energy expenditure, we also conducted the sensitivity analysis by excluding yoga practitioners who engaged in other exercises for a large amount of time. Third, the number of cases in yoga practitioners was limited especially in subgroup analyses. Nonetheless, the associations persisted in direction and trend despite wider confidence intervals. Applying weights to the OR calculation may partially balance the uneven sample size across subgroups and improve the accuracy of the results. Fourth, despite our efforts to control for numerous potential covariates, residual confounding of unmeasured factors cannot be fully ruled out, such as certain lifestyle factors (e.g. sleep) and several physical functional limitations (e.g. disability and fracture), which may introduce biased estimation of the true relationship.

In addition to muscle strength, body flexibility and mental health, engaging in yoga might provide additional health benefits beyond other exercises. Our findings highlighted the potential of yoga as an effective intervention to alleviate multimorbidity burden and promote health for middle-aged and older adults. This may serve to optimize the intervention strategies accordingly, while more prospective studies are warranted to confirm our findings.

Conclusions

In a large, nationally representative sample of US adults aged 45 or above, yoga was found to be significantly associated with lower odds of multimorbidity and individual chronic conditions such as obesity, diabetes, hyperlipidemia, and hypertension, when compared either other exercises or non-exercise. The associations between yoga and multimorbidity were more pronounced in women than in men.

Abbreviations

BRFSS	the Behavioral Risk Factor Surveillance System
OR	odds ratio
CI	confidence interval
MSA	muscle-strengthening activity
CDC	the Centers for Disease Control and Prevention
CAD	coronary artery disease
SCD	subjective cognitive decline
BMI	body mass index

Supplementary Information

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Supplementary Material 1

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Author contributions

Xiang Gao and Liang Sun designed the study; Kaiyue Wang and Peilu Wang performed the statistical analysis, and wrote the manuscript with critical input from all authors; Yaqi Li, Chen Wang, Susan Veldheer, Feifei Wang, Muzi Na, Liang Sun, and Xiang Gao provided critical study oversight and contributed to the critical revision of the manuscript; Xiang Gao and Liang Sun have accessed and verified the data. All authors had full access to all the data in the study and had final responsibility for the submission and publication of the manuscript.

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Data availability
The data are available from the Behavioral Risk Factor Surveillance System (https://www.cdc.gov/brfss/).

Declarations

Ethics approval and consent to participant
This study utilized de-identified data from a publicly available dataset that was exempt from Institutional Review Board approval. All data was anonymized and the consent to participant was not applicable.

Competing interests
The authors declare no competing interests.

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