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Demographic, health behavior, and cardiometabolic risk factor profile in yoga and non-yoga participants: NHANES 1999–2006

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A B S T R A C T

Objective: To examine and compare the demographic, health behavior, and cardiometabolic risk factor characteristics of participants who report 1) participating in yoga, 2) not participating yoga, or 3) are inactive, using a nationally representative sample of U.S. adults.

Design: Study participants were from the 1999–2006 National Health and Nutrition Examination Survey (NHANES) who self-reported participation in yoga (n = 74), no-yoga (n = 3,753) or were inactive (n = 1,285). Participants in the no-yoga group did engage in other types of physical activity, while the inactive group reported no activity during the survey period.

Results: Yoga participants were primarily female (80.7%), college educated (51.9%), mostly non-smokers (46.9%), and reported moderate alcohol consumption (72.1%). Yoga participants were found to be significantly less likely to have an elevated waist circumference (OR = 0.40, $p < 0.01$; OR = 0.30, $p < 0.01$), and a low HDL (OR = 0.43, p = 0.03; OR = 0.34, $p < 0.05$) compared to both non-yoga participants and inactive individuals, respectively. Yoga participants were 61% less likely to have elevated blood glucose compared to non-yoga participants (OR = 0.39, $p < 0.05$). Compared to inactive individuals, yoga participants were 52% (OR = 0.48, $p < 0.05$) and 66% (OR = 0.34, $p < 0.05$) less likely have an elevated body mass index and have elevated triglyceride levels, respectively.

Conclusions: Given the emergence of yoga as a common form of physical activity, it is imperative to understand the characteristics of those who participate in yoga to further understand its relationship with cardiovascular risk. This study was one of the first to use nationally-representative data and objectively measured cardiometabolic variables. ***Key Words***: complementary medicine, epidemiology, survey, population, physical activity, cardiovascular disease

1. Introduction

Yoga is a form of physical and spiritual activity that has been practiced for a few thousand years in Eastern cultures. Yoga became popular in the United States during the 1970's. Presently, over 20 million adults in the U.S. practice yoga and it has been a top 10 fitness trend for the last six years.[1–9] Many individuals practice yoga for health promotion or health maintenance and believe that regular participation will result in improved health and well-being.[3–4,10] Interventions have been conducted to examine the impact of yoga on cardiometabolic risk factors such as glucose,[11] glycosylated hemoglobin levels (HbA1c),[12–13] blood pressure,[14] total cholesterol,[12,14] and mental health. [15–17] While many of these studies do show positive results,[11,13–14] some have not shown significant health improvements after a yoga intervention.[15,17–19] Furthermore, many of the findings from previous research are limited by sample size, lack of details on the specific yoga intervention used, and lack external validity due to studies targeting specific populations. [20]

There is a limited amount of epidemiological research directly comparing individuals who do and do not do yoga regarding cardiometabolic risk factors using nationally representative data. The few studies that have used these data have only examined demographic variables and limited self-reported cardiometabolic risk and mortality characteristics of yoga participants.[3,10,21] This leaves a paucity in the literature describing potential differences in cardiometabolic risk factors, measured objectively, in those who participate or do not participate in yoga in the U.S. Therefore, the purpose of this paper was to examine and compare the demographic, health behavior, and cardiometabolic risk factor characteristics of participants who report participating in yoga, not participating yoga, or are inactive using a nationally representative sample of U.S. adults.

2. Methods

2.1. Study sample

This study utilized eight years of data from the 1999–2006 National Health and Nutrition Examination Survey (NHANES), a continuous

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Table 1
Demographic and health behavior characteristics of fasted participants: NHANES 1999–2006.

Variables	Yoga participants (n = 74)		Non-Yoga Participants (n = 3753)		Inactive (n = 1285)	
Demographics						
Age – mean (SE)	41.3	(1.5)	44.8	(0.5)	46.4	(0.4)
Gender – % (SE)						
Male	19.3	(4.8)	51.1	(0.7)	56.2	(1.7)
Female	80.7	(4.8)	48.9	(0.7)	43.8	(1.7)
Race/Ethnicity – % (SE)						
Non-Hispanic White	88.7	(2.9)	77.1	(1.5)	55.0	(2.9)
Non-White	11.3	(2.9)	22.9	(1.5)	45.0	(2.9)
Education – % (SE)						
Less than High school	1.5	(1.1)*	13.0	(0.8)	40.9	(2.1)
High school/GED	11.9	(3.2)	24.6	(1.0)	29.1	(2.0)
Some College	34.7	(6.3)	32.8	(0.9)	22.7	(1.8)
College graduate	51.9	(6.0)	29.6	(1.4)	7.3	(1.0)
Health Behaviors						
Smoking Status – % (SE)						
Current smoker	19.9	(5.7)	20.7	(1.0)	30.3	(2.0)
Former	33.2	(7.3)	27.7	(0.9)	23.1	(1.7)
Non-smoker	46.9	(7.5)	51.6	(1.3)	46.6	(2.1)
Alcohol consumption – % (SE)						
Non-drinker	11.9	(4.6)*	25.0	(1.6)	40.3	(2.0)
Moderate consumption	72.1	(7.6)	66.9	(1.6)	50.2	(2.3)
Above moderate consumption	16.1	(4.8)	8.1	(0.7)	9.5	(1.2)
Health Eating Index – mean (SE)	53.9	(1.9)	52.5	(0.4)	50.6	(0.3)
Physical Activity – % (SE)						
Inactive	–	–			100.0	(0.0)
Insufficiently Active	15.2	(6.3)*	23.4	(1.0)	–	–
Active	85.1	(3.8)	76.7	(1.0)	–	–
Total MET-min/wk – median (IQR)	1588.0	(739.5-2701.1)	1169.9	(535.7-2235.9)	–	–
Yoga Participation (%)						
Only Yoga	13.6	(3.3)	–	–	–	–
Yoga + Other PA	86.4	(3.3)	–	–	–	–

SE: Standard Error, IQR: Interquartile range, MET: Metabolic Equivalent.
*Relative SE > 30% and < 40%.

survey conducted by the National Center for Health Statistics (National Center for Health Statistics) which provides a representative sample of the civilian, non-institutionalized population of the United States.[22] Full NHANES protocols, including sampling techniques, procedures, and measurement protocols, can be found on their website (http://www.cdc.gov/nchs/nhanes.htm). Per NHANES protocol, prior to participation in the study all participants provided consent to the NHANES staff. The full study sample for the 1999–2006 NHANES was 41,474 participants. For the current study, the sample included U.S. adult (≥20 years of age) participants who self-reported participation in yoga (n = 74), no-yoga (n = 3,753) or were inactive (n = 1,285) and were fasted when examined at the Mobile Examination Center. All study samples met the following inclusion criteria: 1) had data on all variables of interest; and 2) if female, were not pregnant or lactating.

Yoga participants self-reported participation in yoga when asked, "Over the past 30 days, what moderate activity or activities did you do." Following a similar methodology to previous studies[23–24] yoga participation was dichotomized as either yes (yoga was selected) or no (yoga was not selected). Due to the nature of the research question and limitations of sample size, a quantified "dose" of yoga was not examined. Inactive participants were those who responded no to yoga participation and had zero MET-minutes/week of PA, based on selecting no activities engaged in over the last 30 days.

2.2. Variables of interest

Cardiometabolic risk factors included: Elevated systolic (≥130 mmHg or medication) or diastolic (≥80 mmHg or medication) blood pressure,[25] elevated body mass index (BMI) (≥30 kg/m^2), elevated waist circumference (WC) (≥102 cm male, ≥88 cm female),[26] elevated fasting plasma glucose (≥100 mg/dL or medication),[26] elevated fasting insulin and homeostatic model assessment of insulin resistance (HOMA-IR)[27] (≥75th percentile for fasted sample), elevated c-reactive protein (CRP) (> 3 to 10 mg/dL),[28] elevated fasting triglycerides (≥150 mg/dL or medication),[26] elevated low-density lipoprotein cholesterol (LDL-C)(≥160 mg/dL or medication),[26] and lowered high-density lipoprotein cholesterol (HDL-C) (≤ 50 mg/dL male, ≤ 40 mg/dL female or medication).[26]. Participants with a CRP value > 10 mg/dl were excluded from all analyses containing CRP due to this value being representative of acute non-cardiovascular inflammation and not chronic inflammation.[28]

2.3. Covariates

Demographic variables included age, gender, race-ethnicity (non-Hispanic White, non-White), and education (less than high school, high school/GED, some college, college graduate). Health behaviors of interest included: smoking (non-smoker, former smoker, and current smoker), alcohol consumption (non-drinker, moderate consumption, above moderate consumption),[29] Healthy Eating Index (HEI)[30] and physical activity (Total MET-min/wk)[29,31] from three physical activity domains (leisure-time, domestic and transportation).

2.4. Statistical analysis

All variable recodes and analyses were conducted using SAS 9.4 survey procedures (SAS, 2016), which allows for the incorporation of the sampling weights to account for the complex survey design, oversampling of certain groups, non-response, and post-stratification inherent to NHANES (National Center for Health Statistics). Weighted age-adjusted prevalence estimates and mean estimates specific to yoga participation were generated using PROC SURVEYREG. Chi-squared test of independence were used to compare prevalence rates across PA groups. PROC SURVEYREG was also used for all multiple-linear

regression analysis. Two regression models were created. The first examined the differences in cardiometabolic risk factors between yoga compared to non-yoga participants and yoga compared to inactive participants adjusting for the following covariates: age, gender, race-ethnicity, education, smoking, alcohol consumption, and HEI. The second model, solely comparing the yoga and non-yoga participants further adjusted for total MET-min/wk in order to account for the contribution of other physical activities to cardiometabolic risk factors; the process to calculate MET-min/wk specific to NHANES data has been previously detailed elsewhere.[29,31]

3. Results

Table 1 provides the demographic and health behavior characteristics of the study sample. Among those participating in yoga, the overwhelming majority were non-Hispanic white (88.7%), identified as female (80.7%) and met the physical activity guidelines (85.1%). Compared to non-yoga and inactive participants respectively, those participating in yoga had a higher percentage of college graduates (51.9% vs. 29.6% vs. 7.3%), were younger (41.3 vs. 44.8 vs. 46.4 years) and had a higher percentage of participants reporting above-moderate alcohol consumption (16.1% vs. 8.1% vs. 9.5%). Table 2 illustrates the prevalence of cardiometabolic risk factors among those participating in yoga, non-yoga participants, and inactive participants. Chi-squared analysis indicated significant differences between groups ($p < 0.05$) in prevalence rates for elevated blood pressure, blood glucose, fasting insulin, HOMA-IR, triglycerides, BMI, waist circumference, and low HDL. No significant differences were found across groups for elevated CRP and LDL ($p > 0.05$).

Table 3 provides the adjusted odds ratios (OR) for cardiometabolic risk factors comparing yoga to non-yoga participants. Following adjustment for age, gender, race-ethnicity, education, smoking, alcohol consumption, and HEI (model 1), significantly lowered odds were found for elevated waist circumference (OR 0.39, 95% CI 0.20-0.75), elevated blood glucose (OR 0.39, 95% CI 0.18-0.85), and low HDL (OR 0.42, 95% CI 0.20-0.90). Although not statistically significant, clinically meaningful ORs were found for high BMI (OR 0.61, 95% CI 0.32–1.16, $p = 0.12$), elevated triglycerides (OR 0.52, 95% CI 0.23–1.17, $p = 0.11$), and elevated blood pressure (OR 0.66, 95% CI 0.36–1.21, $p = 0.18$). Following further adjustment for total MET-min/wk results remained virtually unchanged. Table 4 provides the adjusted odds ratios for cardiometabolic risk factors comparing yoga to inactive participants. Following adjustment for covariates used in model 1 (Table 3), significantly lowered odds were found for high BMI (OR 0.48, 95% CI 0.23-0.99), elevated waist circumference (OR 0.30, 95% CI 0.15-0.57), low HDL (OR 0.34, 95% CI 0.12-0.98), and elevated triglycerides (OR 0.34, 95% CI 0.14-0.84). Although not statistically significant, clinically meaningful ORs were found for elevated blood sugar (OR 0.46, 95% CI 0.19–1.14, $p = 0.09$), elevated fasting insulin (OR 0.64, 95% CI 0.31–1.33, $p = 0.23$), elevated HOMA-IR (OR 0.60, 95% CI 0.27–1.32, $p = 0.20$), and elevated blood pressure (OR 0.61, 95% CI 0.30–1.24, $p = 0.17$).

4. Discussion

Yoga has become a popular form of exercise over the last decade with the belief that yoga is good for health promotion and/or maintenance; however, there is limited research directly demonstrating health improvements that is specifically generalizable to the U.S. adult population. In the current study, yoga participants were found to be significantly less likely to have an elevated waist circumference and a low HDL compared to both non-yoga participants and inactive

Table 2
Cardiometabolic risk characteristics of fasted participants: NHANES 1999–2006.

Variables	Yoga participants (n = 74)		Non-Yoga Participants (n = 3753)		Inactive (n = 1285)		X^2
Cardiometabolic Risk Factors							
Blood Pressure – %							
Elevated (SBP > 130 mmHg or DBP > 80 mmHg or medication)	28.6	(5.1)	38.6	(1.1)	45.0	(1.9)	$p < 0.05$
Normal	71.4	(5.1)	61.4	(1.1)	55.0	(1.9)	
Blood Glucose - %							
Elevated (≥100 mg/dL or medication)	15.3	(5.4)*	36.0	(1.2)	38.6	(1.9)	$p < 0.05$
Normal	84.7	(5.4)	64.0	(1.2)	61.4	(1.9)	
Fasting Insulin – %							
Elevated (≥75th percentile)	17.7	(5.2)	26.1	(0.8)	34.7	(1.4)	$p < 0.05$
Normal	82.3	(5.2)	73.9	(0.8)	65.3	(1.4)	
Elevated HOMA-IR - %							
Elevated (≥75th percentile)	15.7	(5.3)	25.4	(0.9)	33.8	(1.4)	$p < 0.05$
Normal	84.3	(5.3)	74.6	(0.9)	66.2	(1.4)	
HDL – %							
Low (Male < 40 mg/dL, Female < 50 (mg/dL) or medication)	11.8	(3.4)	27.4	(0.8)	24.7	(1.7)	$p < 0.05$
Normal	88.2	(3.4)	72.6	(0.8)	65.3	(1.7)	
LDL – %							
Elevated (≥160 *mg/dL* or medication)	21.4	(6.7)	22.4	(0.8)	21.8	(1.4)	$p > 0.05$
Normal	78.9	(6.7)	77.6	(0.8)	78.2	(1.4)	
Triglycerides – %							
Elevated (≥150 *mg/dL* or medication)	21.0	(5.9)	35.4	(1.0)	38.5	(1.7)	$p < 0.05$
Normal	79.0	(5.9)	64.6	(1.0)	61.5	(1.7)	
BMI – %							
Not Obese (< 30 kg/m^2)	83.5	(4.5)	70.5	(1.0)	65.1	(1.8)	$p < 0.05$
Obese (≥30 kg/m^2)	16.5	(4.5)	29.5	(1.0)	34.9	(1.8)	
Waist Circumference – %							
Elevated (Male ≥ 102 cm, Female ≥ 88 cm)	26.4	(5.8)	47.8	(1.0)	45.2	(1.7)	$p < 0.05$
Normal	73.6	(5.8)	52.2	(1.0)	54.8	(1.7)	
C – Reactive Protein - %							
Elevated (> 3 – 10 mg/dL)	26.1	(5.2)	24.9	(0.9)	28.5	(1.8)	$p > 0.05$
Normal	73.9	(5.2)	75.1	(0.9)	71.5	(1.8)	

SE: Standard Error, kg/m^2: kilogram per meter-squared, cm: centimeter, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure. mmHg: millimeters of mercury, mg/dL: milligrams per deciliter, BMI: Body Mass Index.
*Relative SE > 30% and < 40%.

Table 3
Odds ratios comparing yoga to non-yoga participants: NHANES 1999–2006.

Variables	Model 1[a]			Model 2[b]		
	Odds Ratio	(95% CI)	p-value	Odds Ratio	(95% CI)	p-value
Obesity (BMI: ≥30 kg/m^2)	0.61	(0.32 – 1.16)	0.12	0.62	(0.32 – 1.20)	0.15
Elevated Waist Circumference (Male ≥ 102 cm, Female ≥ 88 cm)	0.39	(0.20 – 0.75)	0.005*	0.40	(0.21 – 0.77)	0.007*
Elevated Blood Glucose (≥ 100 mg/dL)	0.39	(0.18 – 0.85)	0.02*	0.39	(0.18 – 0.85)	0.02*
Elevated Fasting Insulin (≥75th percentile)	0.88	(0.47 – 1.64)	0.68	0.90	(0.49 – 1.67)	0.74
Elevated HOMA-IR (≥75th percentile)	0.85	(0.44 – 1.67)	0.64	0.88	(0.45 – 1.71)	0.69
Elevated Blood Pressure (SBP > 130 mmHg, DBP mmHg > 80 or medication)	0.66	(0.36 – 1.21)	0.18	0.67	(0.37 – 1.22)	0.18
Elevated LDL (≥160 mg/dL or medication)	1.07	(0.49 – 2.32)	0.86	1.08	(0.50 – 2.33)	0.84
Low HDL (Male < 40 mg/dL, Female < 50 mg/dL, or medication)	0.42	(0.20 – 0.90)	0.02*	0.43	(0.20 – 0.90)	0.03*
Elevated Triglycerides (≥150 mg/dL or medication)	0.52	(0.23 – 1.17)	0.11	0.53	(0.23 – 1.19)	0.12
Elevated C-Reactive Protein (> 3 – 10 mg/dL)	0.92	(0.51 – 1.58)	0.74	0.92	(0.53 – 1.61)	0.78

kg/m^2: kilogram per meter-squared, cm: centimeter, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure. mmHg: millimeters of mercury, mg/dL: milligrams per deciliter, BMI: Body Mass Index.

[a] model 1 adjusted for: age, gender, race-ethnicity, education, smoking, alcohol consumption, and HEI.

[b] model 2 adjusted for all covariates in model 1 plus total MET-hours-week.

* statistically significant.

Table 4
Odds ratios comparing yoga to inactive participants: NHANES.1999–2006.

Variables	Odds Ratio	(95% CI)	p-value
Obesity (BMI: ≥30 kg/m^2)	0.48	(0.23 – 0.99)	0.047*
Elevated Waist Circumference (Male ≥ 102 cm, Female ≥ 88 cm)	0.30	(0.15 – 0.57)	0.0005*
Elevated Blood Glucose (≥ 100 mg/dL)	0.46	(0.19 – 1.14)	0.09
Elevated Fasting Insulin (≥75th percentile)	0.64	(0.31 – 1.33)	0.23
Elevated HOMA-IR (≥75th percentile)	0.60	(0.27 – 1.32)	0.20
Elevated Blood Pressure (SBP > 130 mmHg, DBP mmHg > 80 or medication)	0.61	(0.30 – 1.24)	0.17
Elevated LDL (≥160 mg/dL or medication)	1.19	(0.51 – 2.78)	0.69
Low HDL (Male < 40 mg/dL, Female < 50 mg/dL, or medication)	0.34	(0.12 – 0.98)	0.045*
Elevated Triglycerides (≥150 mg/dL or medication)	0.34	(0.14 – 0.84)	0.02*
Elevated C-Reactive Protein (> 3 – 10 mg/dL)	0.76	(0.44 – 1.33)	0.34

kg/m^2: kilogram per meter-squared, cm: centimeter, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure. mmHg: millimeters of mercury, mg/dL: milligrams per deciliter, BMI: Body Mass Index.
Adjusted for: age, gender, race-ethnicity, education, smoking, alcohol consumption, and HEI.

* statistically significant.

individuals. Blood glucose was more likely to be lower in yoga participants compared to non-yoga participants. Compared to inactive individuals, yoga participants were also less likely to be obese or have elevated triglyceride levels.

Similar to previous research, the current study found the demographic characteristics of yoga participants to be predominantly Caucasian, well-educated females.[3,10] These characteristics have been consistent across different surveys. Birdee et al. (2008) used the National Health Interview Survey (NHIS) and Ross et al. (2012) created their own survey sent solely to Iyengar yoga instructors. For individuals who self-reported yoga participation, these studies found that 76% and 84.2% were female, respectively, while the current study found that 80.7% of participants were female. This study also revealed similar education levels for yoga participants; 51.9% being college graduates, compared to other studies listing between 50–87% of yoga participants having a college degree.[3,10]

Overall, yoga participants appeared be varied in their health behaviors. While there were fewer yoga participants who were current smokers, a higher percentage of participants consumed more alcohol compared to non-yoga participants and inactive individuals. While these data may be surprising, they are similar to patterns from past population-based research in yoga participants.[3] Additionally, the association between being physically active and engaging in moderate drinking habits has been well documented.[32–34] However, these studies have yet to specifically examine engaging in yoga. When examining health behaviors, it is also interesting to note that 86% of yoga participants reported engaging in additional forms of physical activity beyond yoga, with a median amount of 1588 MET·min·week^{-1} of physical activity.

This study is one of the first to examine objectively measured cardiometabolic risk factors in a nationally representative sample of yoga participants and results indicate that individuals who practice yoga are healthier at a biological level. Findings from this study suggest that yoga participants are 60% less likely to have an elevated waist circumference compared to non-yoga participants after accounting for physical activity; only 16.5% of yoga participants had a BMI ≥ 30 kg·m^{-2} compared to 29.5% of participants who did not engage in yoga. Additionally, when compared to inactive individuals, yoga participants were 70% less likely to have an elevated waist circumference and 50% less likely to be obese by BMI standards. 34.9% of the inactive group were classified as obese based on BMI. A retrospective study found similar results by following 15,500 participants over 10 years and asked participants to self-report their height, weight and complete questionnaires related to health behaviors such as yoga practice.[35] Results from Kristal et al., indicated that regular yoga practice had an inverse relationship to BMI in adults in the normal and overweight BMI categories. Adults within the normal BMI range who practiced yoga gained 3.1 lbs. less than their counter parts who did not practice yoga. Individuals who practiced yoga and were classified as overweight gained 18.5 lbs. less than individuals who were overweight and did not practice yoga. Along with gaining less weight, individuals who practiced yoga were 49 to 85% more likely to maintain their weight if they were in the normal or overweight BMI categories, respectively.[35] Interventional studies have found mixed results on the impact of yoga on BMI and/or weight.[36] Yoga may have positive influences on weight; however, it is typically classified as a low or

moderate intensity activity and therefore may not produce a large enough caloric deficit to result in significant weight-loss.[37–38] Because of the cross-sectional study design this study is only able to show associations between BMI and waist circumference to yoga and cannot provide information on cause-effect in the relationship.

Participation in yoga was associated with individuals being 61% and 70% less likely to have elevated blood glucose compared to non-yoga participants and inactive individuals, respectively. In 2008, Cohen et al. reported results of a 10-week randomized controlled trial that included restorative yoga in individuals who were overweight and had metabolic syndrome.[39] After the intervention, yoga participants had a reduction in their oral glucose tolerance test (OGTT) by 6.0 mg/dL, but this was not statistically significant ($p = 0.66$).[39] Hunter, et al. (2013) found significant improvements in OGTT results after an eight-week bikram yoga intervention in individuals who were obese.[12] While there are some conflicting reports, most of the research examining yoga and glucose levels support an inverse relationship. The present study adds to this notion with large differences observed in odds of elevated glucose levels by yoga participation.

Compared to non-yoga participants and inactive individuals, yoga participants were 57% and 66% less likely to have low HDL cholesterol, respectively. Additionally, yoga participants were 66% less likely to have elevated triglyceride levels compared to their inactive peers, but there was no difference compared to non-yoga participants despite a 48% reduction in odds. It is unlikely that these differences are due to diet, reflected by similar group HEI scores of ˜50. Differences between yoga participants and inactive individuals may simply be due to the physical activity that is being performed through yoga. However, there is mixed research regarding the relationship between yoga and cholesterol. Damodaran, et al (2002) conducted a study in 20 participants (35–55 years) with dyslipidemia that assessed effects of 12-weeks of one-hour daily yoga practice on blood lipids. The intervention resulted in a non-significant decrease in total cholesterol of 14.5 mg/dL (pre: 211.0; post: 196.5 mg/dL) and a non-significant increase in HDL-cholesterol of 2.3 mg/dL (pre: 40.0; post: 42.3 mg/dL).[14]

It is somewhat surprising that some of the variables, such as blood pressure and c-reactive protein did not differ by yoga participation. Blood pressure is commonly examined in interventional yoga research and is believed to be greatly influenced by engagement in yoga.[40–42] In contrast there is conflicting literature on the impact of yoga on CRP. There is some support that yoga can improve CRP [43] however, many randomized controlled trials have failed to observe positive findings.[44–48] One possible reason for the difference in findings between past research and this study is the population in question. Many research studies implement a yoga intervention in populations that are at a higher risk for, or are already diagnosed with a chronic illness, such as cardiovascular disease or diabetes. This study examined a nationally representative sample of the U.S., which included healthy individuals, those at risk for and those diagnosed with chronic conditions. Additionally, the sample of yoga participants were younger, 41.1 years, and may not have developed as many risk factors for cardiovascular diseases as individuals who are older.

Although this paper is representative of the national population, this does not show current trends. Since the NHANES years examined (1999–2006), yoga has become even more popular and is a consistent top-ten fitness trend in the U.S. Another limitation is that, compared to the total sample from NHANES data during these years, few people reported engaging in yoga, which limits any ability to examine a dose-response relationship between yoga and risk factors. Although this study has strong external validity, there is no information on the specific styles of yoga that were performed. This information could help to better translate to previous findings in the yoga literature. Lastly, due to the cross-sectional nature of this study, causation or direct relationships cannot be examined between yoga and health variables. Despite limitations, this study did have many strengths. The similar demographic and health behavior results compared to previous literature support the results from this paper. This further strengthens the findings, even though this is the first study done to compare objectively measured health behaviors. Finally, because this study used a nationally-representative dataset the results are more generalizable to the adult U.S. population compared to randomized controlled trials that use a very specific population, specific yoga style, or small sample size.

5. Conclusion

This study is one of the first to use a national-representative sample of U.S. adults to show yoga is associated with favorable health outcomes via objectively measured variables. Specifically, yoga participants had lower odds of obesity, elevated triglycerides, blood glucose, and low HDL. There are many conflicting reports regarding yoga's impact on health; therefore, future research should continue to use rigorous methodology and focus on objectively measured health variables, rather than self-reported health. Given the emergence of yoga as a common form of physical activity, it is imperative to understand the characteristics of those who participate in yoga to further understand its relationship with cardiovascular risk.

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