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SHORT COMMUNICATION

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Health behaviors predicting risk of obesity in US adults: What does a healthy lifestyle look like?

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Abstract

Objective: The purpose of this study was to examine the association between lifestyle factors and body weight in a nationally representative sample of US adults and to evaluate the association between a novel "Healthy Habits Composite Score (HHCS)" and risk of obesity.

Methods: This cross-sectional study included data from 4870 adults who participated in the 2017–2018 National Health and Nutrition Examination Survey (NHANES). The HHCS was developed based on 4 factors: diet, physical activity, sedentary time, and sleep, all of which were measured during the NHANES. A "healthy lifestyle" was defined as meeting ≥3 of the 4 established criteria. Data analysis was conducted using SAS 9.4 and procedures to account for the complex survey design. All models were adjusted for age, sex, race, household income, and education.

Results: Adults with obesity had significantly lower dietary quality (48.8 ± 0.6 vs. 53.2 ± 0.9) and reported significantly more sedentary time (~1 h more; 356.3 ± 7.0 vs. 301.4 ± 8.3 min) than lean adults, both $p < 0.001$. Achieving a healthy lifestyle based on the HHCS was associated with nearly double the odds of having a healthy body weight (OR 1.9, $p < 0.001$).

Conclusions: Following a lifestyle focused on healthy habits (diet quality, physical activity, limited sedentary time, and sleep) was strongly associated with a decreased risk of obesity: an individual who achieved three or more healthy habits had nearly twice the odds of having a healthy body weight. Therefore, comprehensive interventions that address and promote a wide range of healthy habits may be most effective for lowering obesity risk.

KEYWORDS
diet, NHANES, nutrition, obesity, physical activity

1 | INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), achieving and maintaining a healthy weight requires individuals to engage in multiple lifestyle behaviors[1]; these factors include healthy eating,[2] sufficient physical activity,[3] optimal sleep,[4] and stress reduction.[5] However, as studies tend to examine only a single lifestyle behavior in isolation, it is difficult to assess the relative importance and influence of the combination of these factors on body weight among individuals.

"Healthy eating," often thought of as consumption of a high quality diet, has been associated with a significantly lower risk of all-cause mortality, cardiovascular disease, overweight and obesity, type 2 diabetes, and neurodegenerative disease, among other chronic conditions.[6–9] Diet quality can be assessed in many ways and has been broadly defined as a dietary pattern or an indicator of variety across key food groups relative to those recommended in the US dietary guidelines.[10,11] The Healthy Eating Index (HEI) is an established method for evaluating dietary quality that can be used to assess compliance with the US Dietary Guidelines for Americans.[12,13] Studies from the US have found an inverse relationship between HEI score and obesity.[14] Furthermore, the recent 2020–2025 Dietary Guidelines Advisory Committee Report recommends healthy dietary patterns for disease prevention.[7]

The health benefits of physical activity are well-established and include a reduced risk of chronic diseases such as heart disease and diabetes as well as helping to prevent excessive weight gain in adults.[15–17] The *Physical Activity Guidelines for Americans* recommend that adults participate in at least 150 min of moderate-intensity, 75 min of vigorous-intensity, or an equivalent combination of aerobic activity each week, as well as muscle-strengthening activities on 2 or more days a week.[18] At the opposite end of the spectrum, too little physical activity (higher levels of sedentary behavior, or too much sitting) is an established risk factor for cardiometabolic diseases and all-cause mortality.[18] However, the relationship between sedentary behavior and risk of obesity is less clear, with some studies showing a positive correlation[19] and others showing mixed results or no association.[20–22]

In addition to the role of diet and physical activity on body weight, there is emerging evidence evaluating the association of optimal sleep and stress management with the risk of obesity. Adults are recommended to get an average of 7–9 h of quality sleep per night for overall health.[23] Previous research has linked inadequate sleep to an increased risk of certain chronic health conditions, such as heart disease, hypertension, and even obesity.[24–27] The complex relationship between stress, diet, and body weight has also been studied with mixed results.[28]

The purpose of this study was to examine the lifestyle patterns associated with body weight in a nationally representative sample of US adults and to evaluate the association between risk of obesity and a novel "Healthy Habits Composite Score (HHCS)" that includes diet quality, physical activity, sedentary time, and sleep.

2 | METHODS

2.1 | Data source

The National Health and Nutrition Examination Survey (NHANES) is a nationally representative, continuously conducted, cross-sectional survey of US residents. It is administered by the National Center for Health Statistics and the CDC and is designed to monitor the health and nutritional status of the US population. Given the extensive nature of the NHANES data collection, data from the study is uniquely positioned to provide insight on the association between a multitude of lifestyle behaviors (dietary intake, physical activity, sleep patterns, mental health) and measured outcomes, such as body weight and obesity. As part of the NHANES, written consent for participation and demographic characteristics are collected for all participants. Additionally, all NHANES participants undergo a physical examination where height and weight are measured by trained examiners and complete validated surveys and comprehensive questionnaires regarding their health behaviors, including dietary intake, physical activity, sedentary time, sleep, and mental health.

Complete details regarding the NHANES collection of data and sampling methods are available on the NHANES website (https://www.cdc.gov/nchs/nhanes). The present study uses data collected during the NHANES 2017–2018 survey cycle.[29] Two of the major survey objectives for the 2017–2018 cycle were (1) Monitor trends in risk behaviors and (2) Study the relationship between diet, nutrition, and health; both of which are addressed in the present study. Guided by the CDC's National Center for Chronic Disease Prevention and Health Promotion,[1] the following a priori components of a healthy lifestyle were selected for evaluation: healthy eating, physical activity, sedentary time, sleep, and mental health.

2.2 | Components of a healthy lifestyle

2.2.1 | Healthy eating

Dietary intake data was collected as part of the *What We Eat in America* survey module during the in-person examination component of the NHANES (NHANES-WWEIA) by 24-h recall (24HR) using the USDA Automated Multiple Pass Method. This method is a validated and accepted standard for dietary data collection.[30,31] Because the complex sampling strategy of the NHANES includes weighting data, to ensure a proportional distribution of data, 24HR are collected each day of the week and to account for non-response bias, data collected during the 24HR can be used to represent the mean of the population's usual intake.

The Healthy Eating Index-2020 (HEI-2020) is a validated measure of diet quality calculated using dietary intake data; in this study, it was used to assess "healthy eating." Scores for the HEI-2020 can range from 0 to 100, with higher scores conferring better diet quality.[32] To calculate the HEI-2020 score for each participant, the

USDA Food Patterns Equivalents Database, which converts foods and beverages reported during the NHANES-WWEIA into 37 disaggregated food pattern components (e.g.,: total vegetables, alcoholic beverages, added sugars, etc.), was used in addition to the FNDDS to process data.[33] As HEI-2020 is a calculated continuous score, weighted quartiles were calculated to evaluate the distribution of HEI-2020 scores in this nationally representative population of adults. Individuals in the highest quartile of HEI-2020 scores (Q3: HEI $\geq$ 60) represented adults with the healthiest diets in the study population, and thus were considered those with "healthy eating."

2.2.2 | Physical activity

During the NHANES household interview, self-reported data on physical activity was collected directly by trained staff using the Physical Activity Questionnaire (PAQ), a validated questionnaire that provides respondent-level interview data on physical activities and sedentary behaviors. As part of the survey, adults reported the amount of time (in minutes) that they engaged in moderate-intensity and vigorous-intensity sports, fitness and recreational activities, and the number of days they engaged in these activities each week. Physical activity was then categorized using the *Physical Activity Guidelines for Americans*[18] recommendations for physical activity: adults who met the recommended physical activity (achieved at least 150 min of moderate-intensity or 75 min of vigorous-intensity physical activity each week) were considered to have "healthy physical activity."

2.2.3 | Sedentary time

Minutes of daily sedentary time were reported by individuals during the interview portion of the NHANES as another component of the PAQ. Specifically, adults were asked to report the number of minutes of time spent sitting (including time sitting as part of travel/commuting; time reading; time playing cards; time watching television or using a computer). As minimizing sedentary time is an important factor of a healthy lifestyle and there is no universal standard for an acceptable level of time spent sedentary, weighted quantiles of sedentary behaviors were calculated. Individuals in the lowest quartile of sedentary time (Q1; $\leq$180 min/day) were scored as "healthy sedentary behavior," indicating the greatest adherence to the WHO suggestion to limit sedentary time.[34]

2.2.4 | Sleep

Sleep was assessed by self-report during the examination. Individuals who reported meeting the generally recommended 7–9 h of sleep on weekdays or workdays were categorized as having "healthy sleep."

2.2.5 | Stress

Stress is not directly measured during the NHANES examination. Instead, mental health is assessed using the PHQ-9 depression screener. Initial analysis indicated that a small number of participants met the criteria for clinical depression ($n = 151$); as such, measures of stress and/or mental health were not included in the Healthy Habits Composite Score (see below for additional details on the Healthy Habits Composite Score).

2.3 | The Healthy Habits Composite Score

A novel Healthy Habits Composite Score (HHCS) was developed to evaluate the combination of individual lifestyle behavioral components previously identified as factors associated with healthy body weight and other positive health outcomes. The components of the HHCS included those mentioned above: healthy eating, physical activity, sedentary time, and sleep. The HHCS serves as a new and unique way to holistically quantify a "healthy lifestyle" in order to evaluate the relationship between a "healthy lifestyle" and body weight.

For each component of the HHCS, individuals were classified into the "healthy" category (1) or the "unhealthy" category (0). Following component scoring, each individual was assigned an HHCS total score ranging from 0 to 4. For weighted Scott-Rao chi-square tests and logistic regression models, a HHCS of $\geq$3 was used as the criteria for defining a "healthy lifestyle."

2.4 | Statistical analysis

The present study used data from a nationally representative sample of 4870 adults >18 years of age with complete anthropometric, demographic, and dietary data. All data were analyzed using SAS 9.4 (SAS Institute, Cary, NC) using survey procedures to address the complex sampling strategy of the NHANES survey. Demographic characteristics including age, sex, race/ethnicity, household income and educational attainment were assessed using surveymeans and surveyfreq procedures in SAS. The following demographic characteristics were included as covariates in both the multivariable binary logistic regression and multivariable linear regression statistical models: age, sex, race/ethnicity, and total energy intake.

Multivariable linear regression models were used to determine health behaviors comprising the HHCS (dietary intake, physical activity, sedentary time, hours of sleep) across body mass index categories and for the sample as a whole. Weighted Scott-Rao chi-square tests were used for statistical comparison across groups for logistic regression models.[35] Linear regression model results were presented as least-square means and standard error adjusted for age, sex, race/ethnicity, household income, and educational attainment. Nutrient

models were also energy-adjusted. A Taylor Series Linearization was used to approximate all standard errors (SE) for all estimates reported, and statistical comparisons were evaluated using a univariate *t* statistic. A test for linear trend using the Wald statistic was conducted by modeling categories of body weight status as a continuous variable. Multivariable binary logistic regression model results are presented as adjusted odds, controlling for the same factors listed above.

3 | RESULTS

Overall, the mean age of this sample was 46.9 ± 0.4 years, with 73.1% of the adults falling into the BMI category of "overweight" or "obese." Nearly 30% (29.5%) of the total population reported >8 h of sedentary activity daily, while 15.0% of the total population had 3 or fewer hours of sedentary activity. When evaluating dietary intake, the majority (55.8%) of the sample had a "poor" diet (HEI <50), as categorized by HEI-2020 total score.

Table 1 shows the mean for each of the individual health behaviors (dietary quality, weekly physical activity minutes, daily sedentary time, and weeknight hours of sleep) contained in the HHCS by weight status. There was no difference in total caloric intake between lean individuals and those with obesity (2153.1 ± 62.2 vs. 2106.7 ± 34.8 kcals, $p = 0.40$); however, individuals with obesity had a lower diet quality than lean adults with an average HEI score of 48.8 ± 0.6 versus 53.2 ± 0.9 ($p < 0.001$). Only 38.4% of the sample met the recommended guidelines for physical activity. Differences in engagement in physical activity also differed by weight status; a higher percentage of individuals with obesity did not meet the physical activity guidelines compared to lean individuals (29.3% vs. 14.8%, $p < 0.01$), lean adults reported more minutes of weekly activity—nearly double the amount of time spent in vigorous exercise and a third more time spent in moderate exercise. Conversely, a higher percentage of individuals with obesity were classified as having "high sedentary time" (>480 min/day) compared to lean individuals (14.8% vs. 6.5%, respectively). Lean individuals also reported significantly less average daily sedentary time: adults with obesity reported nearly 1 hour more of daily sedentary time than lean adults (356.3 ± 7.0 vs. 301.4 ± 8.3 min/day, respectively; $p < 0.001$). There were no significant differences in average daily weekday sleep time among adults of different weight status categories.

Table 2 shows the odds of being overweight and/or obese by individual lifestyle behaviors in the HHCS component score. Having an unhealthy diet (HEI <60), not meeting physical activity guidelines, and having a sedentary lifestyle were all associated with significantly increased odds of overweight and obesity.

Table 3 shows the relationship between HHCS score and odds of being overweight/obese. HHCS total score had a significant inverse relationship with risk of obesity. Achieving a "healthy lifestyle" (defined as meeting ≥3 out of 4 criteria of the HHCS) was associated with an increased odds of having a healthy body weight. There was a strong linear relationship between odds of being overweight/obese and lack of healthy lifestyle behaviors, whereas achieving a healthy lifestyle was associated with nearly double the odds of having a healthy body weight (OR 1.9, $p < 0.001$).

4 | DISCUSSION

The results of this large nationally representative sample of adults generally replicate what has been previously shown in the literature regarding dietary quality, physical activity, sedentary time, and sleep and their individual relationship with obesity. However, while much of the previous literature has evaluated the role of individual lifestyle factors and risk of obesity, few studies have evaluated lifestyle behaviors comprehensively.[36] The HHCS creates an aggregate score for lifestyle behaviors, allowing for a broader evaluation.

Previous research looking at dietary quality among American adults (average score of 55.3 out of 100 as measured by the HEI-2020) has demonstrated there is much room for improvement.[37] With this sample's average HEI score of 47.4, the findings from this study reinforce the need for improvements in overall dietary quality among the vast majority of US adults; indeed, only 2.0% of the sample population met the standard definition of achieving a "good" quality diet (HEI ≥80). While results from other studies have been somewhat mixed as to the relationship of diet quality and obesity, the current study showed a statistically significant relationship between diet quality/HEI score and weight status, with higher diet quality associated with a healthy body weight (53.2 ± 0.9 vs. 48.8 ± 0.6 in lean vs. obese, $p < 0.0001$).[38] However, what is considered to be clinically significant in terms of improvements/differences in HEI score is not well-defined, although some have suggested a meaningful difference between groups may be 5–6 points.[39,40]

With regard to physical activity, Du et al.[41] showed a much higher percentage of US adults met the recommended physical activity guidelines in earlier cycles of NHANES (2007–2008 and 2015–2016) compared to those in the present study (63.2% and 65.2%, respectively vs. 38.4%, data not shown). While total daily sedentary time of the current sample was slightly lower compared to the 2015–2016 NHANES dataset (374.8 ± 29.2 min/day or ~6.25 h/day vs. ~384 min/day or 6.4 ± 0.2 h/day, respectively), a similar trend between time spent sedentary and body weight emerged: in both the current and 2015–2016 datasets, individuals with obesity had significantly more sedentary time (almost 1 h more) per day compared to lean individuals (both $p < 0.001$).[41]

In addition to diet and physical activity, sleep is considered to be an integral part of human health for its important restorative function.[42] Although research continues to emerge on the potential relationship between sleep and weight, our results indicate that sleep duration was weakly associated with body weight. These findings are consistent with those of Ford et al. who analyzed NHANES data from

TABLE 1 All models are adjusted for age, sex, race/ethnicity, income, and educational attainment.

	Dietary quality		Physical activity—Minutes per week				Sedentary—Minutes per day		Sleep—Hours per night	
	HEI-2020 total score (SE)	*p*-value	Vigorous PA min/wk (SE)	*p*-value	Moderate PA min/wk (SE)	*p*-value	Sedentary min/d (SE)	*p*-value	Sleep hrs (SE)	*p*-value
Lean	53.2 (0.9)	Ref	72.1 (6.6)	Ref	105.9 (10.2)	Ref	301.4 (7.0)	Ref	7.6 (0.1)	Ref
Overweight	51.8 (0.7)	0.17	65.4 (5.7)	0.47	89.5 (7.7)	0.14	315.8 (6.7)	0.19	7.7 (0.1)	0.64
Obese	48.8 (0.6)	<0.0001	41.1 (5.4)	0.002	77.1 (5.7)	0.00	356.3 (8.3)	<0.0001	7.6 (<0.1)	0.52
p-trend		*<0.0001*		*0.001*		*0.01*		*<0.0001*		*0.41*

Note: For all models, "lean" serves as reference category. HEI-2020 Total Score has values of 0–100, with higher values conferring greater diet quality. Physical activity and Sleep quantified using self-reported questionnaire. *p*-trend; this is the test for the linear trend of the relationship.

TABLE 2 Odds presented as adjusted odds ratios controlling for age, sex, race/ethnicity, household income, and educational attainment.

	OR	95% CI		*p*-value
Odds of having BMI >25 kg/m^2 by HHCS component				
Unhealthy diet	1.6	1.2	2.2	0.004
Does not meet PA guidelines	1.3	1.1	1.7	0.02
High sedentary behavior	1.7	1.3	2.4	0.002
Unhealthy sleep	1.04	0.8	1.3	0.72
Odds of having BMI >30 kg/m^2 by HHCS component				
Unhealthy diet	2.1	1.7	2.5	<0.0001
Does not meet PA guidelines	1.7	1.3	2.2	0.0007
High sedentary behavior	1.7	1.3	2.3	0.0007
Unhealthy sleep	1.1	0.9	1.4	0.47

Note: "Healthy" as assessed via the Healthy Habits Composite Score (HHCS) defined in the text.

TABLE 3 Odds ratios modeled as odds of BMI >25.0 kg/m^2, adjusted for age, sex, race/ethnicity, household income and educational attainment.

	Odds of being overweight/obese			
	OR	95% CI		*p*-value
# HHCS criteria met				
1 versus 4	4.8	2.2	10.2	0.0006
2 versus 4	3.3	1.7	6.6	0.002
3 versus 4	2.3	1.03	5.1	0.04
Overall health category				
Unhealthy versus healthy	1.9	1.4	2.5	0.0002

Note: "Healthy" as assessed via the Healthy Habits Composite Score (HHCS) defined as meeting 3 of 4 criteria from: Healthy Diet, Healthy Physical Activity (encompassing Exercise & Sedentary behavior), and Healthy Sleep.

the 2005–2010 cycles (n = 11,789 participants) and found that short sleepers (≤6 h/night) compared to those who averaged 7–9 h of sleep per night were more likely to be obese (adjusted prevalence ratio: 1.1, 95% confidence interval [CI]: 1.03, 1.2). Other researchers have reported mixed findings emphasizing the need for continued research in this area.[43,44]

In the current study, dietary quality, physical activity, time spent sedentary, and sleep were individually associated with body weight. This analysis also indicated that the overall US adult population does not meet the individual recommendations for healthy lifestyle behaviors. When looked at more comprehensively, as assessed via the HHCS, the odds of an individual being overweight or obese decreased with each "healthy habit" met, such that an individual who met only one of the HHCS criteria had nearly five times the odds of being overweight or obese (OR 4.8 95% CI 2.2–10.2, $p < 0.001$). Comparatively, an individual who achieved three or more healthy habits (considered "healthy" via the HHCS) had nearly twice the odds of having a healthy body weight (OR 1.9, 95% CI 1.4–2.5, $p < 0.001$).

The results of this secondary analysis showing an association between various lifestyle factors and risk of obesity suggest that the use of comprehensive interventions that address and promote a wide range of healthy habits may be the most effective at lowering the risk of obesity.

A primary strength of this study was the use of the NHANES data for the analysis. The NHANES data is nationally representative of the US population, making the results generalizable. While there are innate limitations on the potential accuracy of self-reported data, these data were collected using rigorous quality control procedures by trained professionals increasing reliability. It is notable that a very small percentage of the study population (2.0%) met the standard definition for "good" diet quality (HEI of 80 or above); therefore, the categorization of "healthy eating" warrants interpretation with caution.

Although some may view the use of the HHCS as a potential limitation because it has not been previously validated, to our knowledge this is the first study to have looked at the association of diet, physical activity, sedentary time, and sleep on body weight both as individual factors and as a single composite score of these components combined. We believe the use of this novel HHCS is a more robust and pragmatic approach as it takes into the consideration the relationship of the combination of several individual lifestyle behaviors with body weight rather than examining each behavior only in isolation.

5 | CONCLUSION

There are several implications and applications for the results of this study. The findings of this secondary analysis emphasize the importance and interconnectedness of the combination of healthy habits on body weight, including healthy eating, sufficient physical activity, limited sedentary time, and adequate sleep. Use of the HHCS may be a novel approach for qualifying what constitutes a "healthy lifestyle," as it is not just the individual but the combination of factors that appears to be most impactful.

These findings emphasize the importance of developing and continuing to support a variety of healthy habits, including healthy eating, adequate physical activity, limited sedentary time, and sleep, for maintaining a healthy body weight. Furthermore, comprehensive weight management interventions addressing these factors may be the most effective for lowering obesity risk and therefore promoting long-term health and wellbeing.

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CONFLICT OF INTEREST STATEMENT

JRK, CDC, and SSJ are all employees of Medifast, Inc., who sponsored this secondary data analysis. JAV received consulting fees from Medifast, Inc.

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