Associations among Physical Activity, Diet Quality, and Weight Status in US Adults

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ABSTRACT

PATE, R. R., S. E. TAVERNO ROSS, A. D. LIESE, and M. DOWDA. Associations among Physical Activity, Diet Quality, and Weight Status in US Adults. *Med. Sci. Sports Exerc.*, Vol. 47, No. 4, pp. 743–750, 2015. **Purpose**: Nearly 70% of adult Americans are overweight or obese, but the associations between physical activity, diet quality, and weight status have not been examined in a representative sample of US adults. The purpose of this study was to examine the associations among moderate-to-vigorous physical activity (MVPA), diet quality, and weight status within and across age groups in US adults. **Methods**: Participants included 2587 men and 2412 women age 20 to ≥70 yr from the National Health and Nutrition Examination Survey 2003–2004 and 2005–2006. Physical activity was measured by accelerometry. Diet quality was assessed with overall Healthy Eating Index-2005 scores. Measures of weight status, body mass index (BMI), and waist circumference were assessed using standard National Health and Nutrition Examination Survey protocols. **Results**: Across age groups, MVPA was lower in the older age groups for both men and women, whereas diet quality was higher ($P < 0.001$). BMI and waist circumference were also higher in the older age groups ($P < 0.05$). Within age groups, MVPA was inversely associated with BMI and waist circumference for men and women in nearly every age group ($P < 0.05$). Diet quality was inversely associated with the weight status variables only in men age 30–39, 40–49 (BMI only), and 50–59 yr and women age 50–59 yr ($P < 0.05$). **Conclusions**: We observed clear age-related trends for measures of weight status, physical activity, and diet quality in US men and women. MVPA was very consistently related to weight status in both genders. The relation between diet quality and weight status was less consistent. These findings provide support for public health efforts to prevent obesity by promoting increased physical activity in adult Americans. **Key Words:** SURVEY DATA, AGE TRENDS, NATIONALLY REPRESENTATIVE SAMPLE, NHANES, ACCELEROMETRY, PUBLIC HEALTH

The prevalence of obesity has nearly tripled in adult Americans since the 1980s (11,12), and reversing this trend has become a major public health goal (43). It is clear that obesity results from chronic positive energy balance (17,46), and it is also clear that this condition can result from excessive dietary energy intake, low energy expenditure due to low levels of physical activity, or both (24). Although the individual-level behaviors that can produce obesity are well recognized, the population-level changes that explain the dramatic secular increase in the prevalence of obesity remain controversial. Some have claimed that the obesity epidemic can be explained largely by adverse changes in population-level dietary behavior (2,38), whereas others have pointed to declining physical activity levels as the most salient factor (1,8). Many public health authorities have recommended that promotion of both healthy eating and physical activity be used to address the obesity epidemic (23,47).

The US government has established public health guidelines for both diet and physical activity (28,41). These guidelines recommend behaviors intended to provide a broad range of health benefits, including reduced risk for developing overweight and obesity. The "Dietary Guidelines for Americans" recommend that adults "select a healthy eating pattern that includes nutrient-dense foods and beverages they enjoy, meets nutrient requirements, and stays within calorie needs" (40). The "Physical Activity Guidelines for Americans" recommend that adults engage in at least 150 min of moderate-intensity physical activity per week or the equivalent amount of more vigorous activity. The physical activity guidelines include the following statement: "Strong scientific evidence shows that physical activity helps people maintain a stable weight over time" (42).

If the assertions cited above are correct, it would be reasonable to expect that the level of compliance with the dietary guidelines and the physical activity guidelines would be related to weight status in the adult population. In addition, if both diet and physical activity, as indicated in

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the federal guidelines, contribute to prevention of overweight, it would be expected that each behavior would be independently related to weight status. The central elements of both sets of guidelines are applied uniformly across the adult age range and to both men and women. Therefore, one would expect to observe favorable associations between engagement in healthy physical activity and dietary behaviors as outlined within the two sets of guidelines and weight status in all adult age groups and in both genders.

Surprisingly, no previous study has examined the associations between weight status, diet quality, and physical activity in nationally representative age/gender subgroups of the adult population in the United States. We have selected two measures that assess select components of compliance with the dietary guidelines (Healthy Eating Index-2005 (HEI-2005)) and the physical activity guidelines (moderate-to-vigorous physical activity (MVPA)). The HEI-2005 is a measure of diet quality that assesses conformance to dietary guidelines in relation to the quality components (15,19). MVPA is a measure of compliance with regard to meeting the key recommendation of at least 150 min of MVPA per week. Accordingly, the objectives of this study were as follows: 1) to examine age-related trends in MVPA, diet quality, and weight status in US adults and 2) to examine the associations among MVPA, diet quality, and weight status within age/gender groups of US adults age 20 to ≥70 yr. We investigated these relations in a nationally representative sample of adult Americans included in the 2003–2004 and 2005–2006 rounds of the National Health and Nutrition Examination Survey (NHANES).

METHODS

Study Design

A cross-sectional study design was used using data from NHANES. NHANES is conducted by the Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics and includes a representative sample of the US civilian noninstitutionalized population. The sample was obtained using a complex, multistage probability design. The standard NHANES protocol included interviewing participants at their homes followed by a health examination at a mobile examination center. The protocol was approved by the National Center for Health Statistics Institutional Review Board, and all participants provided written informed consent before participation.

Participants

The current study is based on data from 7675 participants age 20 to ≥70 yr from the 2003–2004 and 2005–2006 rounds of NHANES. Approximately 48.0% of the sample was male, the mean age was 49.9 ± 18.8 yr, and 31.3% of participants were normal weight. The majority of the sample was non-Hispanic white (51.9%), followed by non-Hispanic black (20.7%), Mexican American (20.4%), other race (4.1%), and other Hispanic (2.9%). Participants were excluded if they had missing data on the following: objectively measured physical activity (<4 d of accelerometer data (n = 1496), MVPA >300 min·d^{-1} (n = 12)), two reliable 24-h dietary recalls (n = 796), body mass index (BMI) or waist circumference (n = 119), age (n = 0), race/ethnicity (n = 0), poverty income ratio (n = 224), and smoking (n = 1). We did not include women who were or may have been pregnant or who were breastfeeding (n = 28). After deletions, this resulted in a final analysis sample of 4999 adults age 20 to ≥70 yr (2587 men and 2412 women). The final sample was slightly older and more educated, had higher poverty income ratio and diet quality, and included fewer Mexican Americans compared with those who were excluded because of missing data; the samples did not differ in terms of BMI, waist circumference, or physical activity (accelerometry).

Participants were categorized into five racial/ethnic groups (i.e., non-Hispanic white, non-Hispanic black, Mexican American, other race, and other Hispanic). The poverty income ratio, which takes into account both family size and income, was used as an index of socioeconomic status (range, 0 to 5) (7). Education level was recoded as high school or less and greater than high school. Marital status was recoded as married/living with partner and not married. Smoking status was determined with the question "Do you now smoke cigarettes?" A second item was used, "How long has it been since you quit smoking cigarettes?" Participants were coded as "nonsmoker," "former smoker," and "current smoker."

Measures

Physical activity. Participants were asked to wear an ActiGraph model 7164 accelerometer (ActiGraph, LLC, Ft. Walton Beach, FL) on their right hip on an elastic belt for seven consecutive days following the mobile examination. Participants were asked to wear the monitor during most waking hours, except when sleeping or doing water-related activities (e.g., bathing or swimming). Monitors were returned by express mail, and data were downloaded and reviewed by National Center for Health Statistics staff. Data were collected and stored in 1-min intervals.

For the current analyses, a valid day for measurement of physical activity with accelerometry was defined as having 10 h or more of wear time. Nonwear time, defined as any period of 60 min or more with no counts recorded, was recoded as missing. Only participants who wore the monitor for at least 4 d for 10 h or more per day were included in the analyses. Intensity thresholds were based on the procedures described by Troiano et al. (39). The threshold for MVPA intensity was ≥2020 counts per minute (≥3 METs). This cut-point was applied uniformly for all age groups and both genders, and because of variability in fitness, relative intensity for MVPA likely varied across groups. Time spent in MVPA (minutes per day) was determined by summing the minutes in a day that met the criterion and averaging for all days with 10 h or more of wear time.

Diet quality. Dietary data were collected with a 24-h dietary recall administered by trained interviewers on two nonconsecutive days, one at the mobile examination and the second 3–10 d later by telephone. Interviewers used a computerized automated multipass method (31). During both interviews, participants were asked to recall all food items and the corresponding amount consumed from midnight to midnight on the day preceding the interview. At the in-person interview, participants were given a set of measuring guides to help them report the amount of foods consumed, and the guides were reused for the subsequent telephone interview.

The HEI-2005 was calculated from dietary recall data to provide a summary score that is reflective of overall diet quality (10). This tool was developed by the US Department of Agriculture's Center for Nutrition Policy and Promotion and has been deemed a valid measure of diet quality (15). The overall HEI-2005 score is the sum of scores for 12 dietary components, including nine adequacy components (e.g., total fruit and whole grains) and three moderation components (e.g., saturated fat and sodium). HEI-2005 score is calculated on a per calorie basis and is therefore adjusted for energy intake. Higher HEI-2005 scores indicate better diet quality; the maximum possible score is 100. The mean

TABLE 1. Sample characteristics (weighted mean and SE or percentage) according to gender and age groups.

Characteristic						
Men						
Age group (yr)	20–29	30–39	40–49	50–59	60–69	≥70
n	353	405	470	364	445	550
Age (yr)	24.8 (0.2)	34.7 (0.2)	44.6 (0.2)	53.8 (0.2)	64.2 (0.1)	76.3 (0.2)
Poverty index	2.6 (0.1)	3.2 (0.1)	3.5 (0.1)	3.7 (0.1)	3.4 (0.1)	2.8 (0.1)
Race						
Non-Hispanic white	63.6%	66.7%	77.6%	76.5%	84.1%	86.1%
Non-Hispanic black	10.6%	9.0%	9.8%	8.4%	7.1%	7.5%
Mexican American	11.6%	11.9%	7.7%	4.4%	4.1%	2.8%
Other race	8.5%	6.8%	2.0%	7.4%	3.6%	0.9%
Other Hispanic	5.7%	5.5%	2.9%	3.2%	1.1%	2.8%
Education						
HS or less	42.3%	42.3%	37.0%	34.6%	43.2%	53.6%
Higher than HS	57.7%	57.7%	63.0%	65.4%	56.8%	46.4%
Marital status						
Married/partner	50.0%	73.1%	80.4%	82.4%	83.4%	77.9%
Not married	50.0%	26.9%	19.6%	17.6%	16.6%	22.1%
Body weight (kg)	83.8 (1.5)	88.8 (1.2)	91.6 (0.8)	88.8 (1.2)	91.1 (1.2)	83.3 (0.8)
Weight status						
Underweight	4.0%	0.5%	0.2%	1.5%	0.1%	0.9%
Normal weight	43.0%	30.5%	18.6%	20.5%	18.1%	27.3%
Overweight	29.6%	39.0%	46.5%	43.6%	45.9%	45.6%
Obese	23.4%	30.0%	34.8%	34.4%	36.0%	26.2%
Smoking status						
Nonsmoker	53.3%	56.1%	45.9%	39.2%	26.7%	32.1%
Former smoker	17.3%	18.9%	26.8%	35.0%	53.8%	62.1%
Current smoker	29.4%	25.0%	27.3%	25.8%	18.5%	5.8%
Women						
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	264	336	469	376	473	494
Age (yr)	24.7 (0.2)	34.7 (0.2)	44.4 (0.2)	54.2 (0.2)	64.1 (0.1)	76.7 (0.3)
Poverty index	2.6 (0.1)	3.2 (0.1)	3.4 (0.1)	3.6 (0.1)	3.0 (0.1)	2.5 (0.1)
Race						
Non-Hispanic white	66.7%	73.2%	71.5%	78.8%	79.3%	87.0%
Non-Hispanic black	10.5%	11.5%	12.7%	9.5%	9.8%	5.7%
Mexican American	10.2%	9.6%	6.6%	4.4%	3.7%	3.0%
Other race	6.8%	2.5%	5.1%	4.3%	4.4%	3.3%
Other Hispanic	5.8%	3.1%	4.1%	3.0%	2.8%	1.0%
Education						
HS or less	29.7%	31.5%	33.5%	36.5%	48.4%	64.0%
Higher than HS	70.4%	68.5%	66.5%	63.5%	51.6%	36.0%
Marital status						
Married/partner	46.5%	76.2%	70.0%	67.2%	63.3%	44.3%
Not married	53.5%	23.8%	30.0%	32.8%	36.7%	55.7%
Weight (kg)	69.7 (1.3)	76.0 (1.2)	77.6 (1.1)	77.4 (1.5)	76.3 (0.9)	68.8 (1.3)
Weight status						
Underweight	2.9%	0.9%	1.8%	1.0%	0.9%	2.1%
Normal weight	53.2%	40.0%	31.8%	31.8%	27.6%	36.7%
Overweight	22.7%	21.6%	28.1%	30.1%	37.3%	35.4%
Obese	21.2%	37.5%	38.4%	37.2%	34.2%	25.8%
Smoking status						
Nonsmoker	65.2%	62.8%	55.1%	59.6%	52.8%	58.1%
Former smoker	11.1%	15.3%	22.0%	23.8%	31.3%	36.2%
Current smoker	23.7%	21.9%	23.0%	16.6%	15.8%	5.7%

HS, high school. Underweight, BMI <18.5; normal weight, BMI 18.5–24.9; overweight, BMI 25–29.9; obese, BMI ≥30.

HEI-2005 score from the two dietary recalls was used in the analyses (14,26).

Weight status. Anthropometric measurements were administered by trained staff with the participants wearing light clothing without shoes, using standardized methods and equipment (5). Height and weight were used to calculate BMI using the standard equation weight (kg)/height (m)^2. For descriptive purposes, participants were categorized into four weight categories: BMI <18.5 (underweight), BMI 18.5–24.9, BMI 25–29.9 (overweight), and BMI ≥30 (obese) using CDC criteria (6). All subsequent analyses included BMI as a continuous variable. Waist circumference was measured at the uppermost lateral border of the ilium to the nearest 0.1 cm.

Statistical Analysis

Descriptive statistics included weighted means (SE) or percentages for demographic, anthropometric, physical activity, and diet quality variables, according to gender and age groups. All analyses were conducted on the weighted data using SAS (version 9.3, SAS institute, Cary, NC) in 2013; the Surveyreg procedure was used to account for the complex NHANES survey design. Sample weights were recalculated to ensure that the final analysis sample remained nationally representative (33). Because two NHANES cycles were used (2003–2004 and 2005–2006), 4-yr sample weights were applied to the data. Gender-specific analyses were conducted to test for linear trends for BMI, waist circumference, diet quality, and MVPA across six age groups: 20–29, 30–39, 40–49, 50–59, 60–69, and ≥70 yr. The following variables were included in the analyses as covariates because of their known relation with weight status, physical activity, and diet quality: race/ethnicity, poverty income ratio, and smoking status.

To examine associations between the behavioral variables (MVPA, diet quality) and the weight status variables (BMI, waist circumference), regression analyses were performed separately for men and women within the age groups (using the Domain statement in SAS). Regression coefficients and 95% confidence intervals were calculated to determine the independent contributions of MVPA (model 1), diet quality (model 2), and MVPA and diet quality (model 3) in predicting BMI and waist circumference. All models were adjusted for the covariates age, race/ethnicity, poverty income ratio, and smoking status. Statistical significance was set at $P < 0.05$.

RESULTS

Sociodemographic characteristics for each of the six age groups by gender are presented in Table 1. For the total analysis sample, the race/ethnicity distribution was 74.8% non-Hispanic white, 9.7% non-Hispanic black, 7.1% Mexican American, 4.8% other race, and 3.6% other Hispanic. The weighted and unadjusted means (SE) for weight status, MVPA, and overall HEI-2005 score according to gender and age group are presented in Table 2. Approximately 32.2% of participants were classified as obese, and an additional 34.7% were classified as overweight.

Adjusted analyses with the weighted data revealed significant age-related trends in weight status, physical activity, and diet quality in both men and women. There were positive age-related trends for waist circumference across the age groups in both genders ($P < 0.001$) and a significant positive age-related trend for BMI in men only ($P < 0.05$). For the behavioral variables, we observed a significant negative age-related trend for MVPA in both men and women ($P < 0.001$). There was also a significant positive age-related trend in diet quality (overall HEI-2005 score) for both men and women ($P < 0.001$).

Adjusted regression analyses examining the associations of MVPA and diet quality with BMI and waist circumference were performed in each of the six age groups by gender. The results for men are presented in Table 3. In model 1, MVPA was significantly inversely associated with BMI in five of the six age groups ($P < 0.05$) and with waist circumference in all six age groups ($P < 0.05$). With the exception of the 20- to 29-yr age group, these associations remained significant and were essentially unaffected by the inclusion of diet quality in the model (model 3). In model 2, diet quality was inversely associated with both BMI and waist circumference in three of the six age groups of men (30–39, 40–49, and 50–59) ($P < 0.05$). With the exception of waist circumference in the 40- to 49-yr age

TABLE 2. Unadjusted and weighted means (SE) for weight status, physical activity, and diet quality.

Characteristics						
Men						
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	353	405	470	364	445	550
Waist circumference	92.9 (1.0)	99.1 (0.8)	102.6 (0.7)	102.9 (0.9)	107.3 (0.8)	104.2 (0.6)
BMI	26.5 (0.4)	28.5 (0.3)	29.0 (0.3)	28.4 (0.3)	29.4 (0.3)	27.7 (0.2)
MVPA (min·d^{-1})	41.4 (1.9)	38.8 (1.4)	35.8 (1.2)	26.5 (1.3)	17.6 (0.9)	9.3 (0.6)
Diet quality (HEI-2005)	49.6 (0.9)	50.1 (0.6)	50.8 (0.7)	52.7 (0.7)	54.7 (0.7)	56.8 (0.7)
Women						
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	264	336	469	376	473	494
Waist circumference	87.5 (1.1)	92.7 (1.0)	94.5 (0.8)	96.2 (1.3)	97.7 (0.6)	95.4 (1.0)
BMI	26.1 (0.5)	28.6 (0.5)	29.2 (0.4)	29.3 (0.5)	28.9 (0.3)	27.3 (0.4)
MVPA (min·d^{-1})	24.9 (1.3)	23.6 (1.1)	21.9 (1.0)	16.4 (1.0)	12.0 (0.8)	6.3 (0.4)
Diet quality (HEI-2005)	51.3 (0.7)	53.2 (0.7)	53.4 (0.7)	56.1 (0.8)	58.0 (0.7)	59.7 (0.6)

TABLE 3. Associations between physical activity, diet quality, and weight status (beta, 95% confidence interval) for men.

			BMI			
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	353	405	469	364	445	550
Model 1						
MVPA (min·d^{-1})	−0.02	−0.06***	−0.05***	−0.04*	−0.08***	−0.07***
	−0.04, −0.003	−0.09, −0.03	−0.06, −0.03	−0.06, −0.01	−0.11, −0.04	−0.11, −0.04
Model 2						
Diet quality, HEI-2005	−0.04	−0.08**	−0.06*	−0.08*	0.01	−0.01
	−0.11, 0.03	−0.13, −0.03	−0.10, −0.01	−0.13, −0.02	−0.06, 0.07	−0.06, 0.04
Model 3						
MVPA (min·d^{-1})	−0.02	−0.06***	−0.04***	−0.04*	−0.08***	−0.07***
	−0.04, −0.003	−0.09, −0.03	−0.06, −0.02	−0.07, −0.01	−0.11, −0.05	−0.11, −0.03
Diet quality, HEI-2005	−0.04	−0.08*	−0.05*	−0.08**	0.01	0.001
	−0.10, 0.03	−0.13, −0.02	−0.09, −0.001	−0.13, −0.03	−0.05, 0.07	−0.05, 0.05
			Waist Circumference			
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	353	405	470	364	445	550
Model 1						
MVPA (min·d^{-1})	−0.06*	−0.16***	−0.12***	−0.11*	−0.22***	−0.22***
	−0.13, −0.001	−0.23, −0.09	−0.17, −0.07	−0.19, −0.03	−0.31, −0.13	−0.32, −0.12
Model 2						
Diet quality, HEI-2005	−0.18	−0.22**	−0.14*	−0.24***	−0.06	−0.002
	−0.39, 0.03	−0.36, −0.08	−0.26, −0.03	−0.37, −0.12	−0.20, 0.08	−0.13, 0.12
Model 3						
MVPA (min·d^{-1})	−0.06	−0.16***	−0.12***	−0.12*	−0.22***	−0.22***
	−0.12, 0.001	−0.22, −0.09	−0.17, −0.07	−0.20, −0.03	−0.31, −0.13	−0.33, −0.12
Diet quality, HEI-2005	−0.17	−0.21*	−0.11	−0.25***	−0.06	0.02
	−0.37, 0.04	−0.36, −0.06	−0.23, −0.002	−0.37, −0.14	−0.19, 0.07	−0.11, 0.16

Model 1, MVPA only; model 2, diet quality only; model 3, all variables entered. All models adjusted for age, race/ethnicity, poverty income ratio, and smoking status.
*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

group, controlling for the effect of MVPA (model 3) had little effect on the associations of diet quality with the measures of weight status.

The associations of MVPA and diet quality with BMI and waist circumference in women are shown in Table 4. MVPA was significantly inversely associated with both BMI and waist circumference in five of the six age groups for model 1 ($P < 0.05$). These associations were largely unaffected by adding diet quality to the models (model 3). In most of the age groups for women, diet quality was not significantly

TABLE 4. Associations between physical activity, diet quality, and weight status (beta, 95% confidence interval) for women.

			BMI			
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	264	336	469	375	473	494
Model 1						
MVPA (min·d^{-1})	−0.05*	−0.03	−0.11***	−0.11***	−0.09**	−0.11***
	−0.09, −0.01	−0.07, 0.01	−0.14, −0.07	−0.14, −0.08	−0.14, −0.04	−0.17, −0.06
Model 2						
Diet quality, HEI-2005	−0.06	−0.01	−0.06	−0.09*	−0.05	−0.04
	−0.14, 0.03	−0.09, 0.08	−0.15, 0.03	−0.16, −0.02	−0.11, 0.01	−0.09, 0.004
Model 3						
MVPA (min·d^{-1})	−0.05*	−0.02	−0.10***	−0.11***	−0.09**	−0.11**
	−0.08, −0.01	−0.07, 0.01	−0.14, −0.06	−0.14, −0.08	−0.14, −0.04	−0.17, −0.05
Diet quality, HEI-2005	−0.05	−0.01	−0.04	−0.08*	−0.02	−0.03
	−0.13, 0.04	−0.08, 0.09	−0.12, 0.05	−0.15, −0.01	−0.08, 0.03	−0.07, 0.02
			Waist Circumference			
Age group	20–29	30–39	40–49	50–59	60–69	≥70
n	264	336	469	375	473	494
Model 1						
MVPA (min·d^{-1})	−0.17***	−0.05	−0.23***	−0.24***	−0.19*	−0.29***
	−0.26, −0.08	−0.13, 0.04	−0.30, −0.14	−0.33, −0.15	−0.34, −0.03	−0.45, −0.15
Model 2						
Diet quality, HEI-2005	−0.18	−0.03	−0.11	−0.23**	−0.09	−0.09
	−0.42,-0.04	−0.18, 0.11	−0.30, 0.08	−0.36, −0.10	−0.24, 0.05	−0.23, 0.06
Model 3						
MVPA (min·d^{-1})	−0.15**	−0.04	−0.22***	−0.23***	−0.18*	−0.29**
	−0.25, −0.06	−0.13, 0.04	−0.31, −0.13	−0.33, −0.14	−0.34, −0.03	−0.45, −0.12
Diet quality, HEI-2005	−0.14	−0.02	−0.06	−0.22**	−0.05	−0.04
	−0.34, 0.07	−0.17, 0.13	−0.24, 0.12	−0.35, −0.09	−0.18, 0.09	−0.19, 0.10

Model 1, MVPA only; model 2, diet quality only; model 3, all variables entered. All models adjusted for age, race/ethnicity, poverty income ratio, and smoking status.
*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

associated with either BMI or waist circumference. The exception was the 50- to 59-yr-old group, in which diet quality was significantly inversely associated with both BMI and waist circumference ($P < 0.05$).

DISCUSSION

The major finding of this study was that participation in MVPA was very consistently inversely related to measures of weight status in US adults. This pattern was observed in both men and women in the analyses performed within age groups and in the analyses examining trends across the age groups. With great consistency, higher levels of physical activity were associated with lower BMI and lower waist circumference. These relations were largely unaffected by adjustments for race/ethnicity, socioeconomic status, smoking, age (within age categories), and diet quality. These findings, although limited by the cross-sectional nature of the NHANES data, provide support for efforts to prevent obesity through promotion of increased physical activity in American adults.

The findings for relations between diet quality and weight status were much less consistent than for physical activity. Better diet quality was significantly associated with lower BMI in three of six age groups for men and with lower waist circumference in two of six age groups for men. Better diet quality was significantly associated with lower BMI and waist circumference in only one age group for women (50–59 yr). The inconsistency of these findings may be explained, in part, by the limitations associated with measurement of dietary behavior in large surveys. In NHANES, diet was measured via interviewer-administered diet recall for two 24-h periods. We used this self-reported dietary data to calculate the HEI-2005, which we used as the measure of overall diet quality. Although this diet assessment approach is well established and widely applied, and the HEI is a validated approach to measuring dietary quality (15,19), having three or more dietary recalls would have been preferable. Measurement error research is still evolving for the study of dietary indices and ratio measures such as the HEI. What is known to date suggests that the energy adjustment built into the HEI may be countering some of the attenuating effects of nondifferential misclassification. However, although the statistical significance tests of the association may not be seriously biased, they most likely do not have adequate statistical power (13). Thus, the nonsignificant findings for the associations of diet quality and weight status should be treated with due caution.

The design and methodology of the present study are unique, but the findings are generally consistent with the existing literature examining relations among physical activity, diet quality, and measures of weight status in adults. We observed, on a very consistent basis, significant inverse relations between physical activity and the two measures of weight status considered in this study. This observation is consistent with previous studies that have examined similar relations using cross-sectional study designs in large samples (27,30,34,36,37,44). It is also consistent with the findings of studies using prospective, observational designs to examine the relation between physical activity and measures of weight status in adults (20–22,27,32,36). We found less consistency in terms of statistical significance of findings in our examination of the relation between diet quality and weight status measures. In the current study, higher diet quality was inversely associated with measures of weight status in three of six age groups for men and only one of six age groups for women. Previous studies have reported significant inverse relations between diet quality and weight change or body composition in adults (9,20,30). However, these studies pooled participants across age groups and reported marked gender differences.

A recently published study by Loprinzi et al. (26) using NHANES data found that both physical activity and diet quality were associated with risk of overweight/obesity in US adults. However, the study design and analytic strategies used in the current study are very different from those used in the Loprinzi study. The current study examined these relations in age and gender subgroups, and the variables were treated continuously. We have examined our exposure variables in the full analysis sample (adjusting for age, gender, and other covariates), and like Loprinzi and colleagues, we found significant inverse relations between both physical activity and diet quality with weight status. However, the current study expands and complements that of Loprinzi et al. by providing detailed information about how these variables interact within different subgroups of the US population.

It is well known that US men and women gain weight and fat as they age (18,25,29,45). However, to our knowledge, this is the first study to comprehensively document age-related trends in weight status, physical activity, and diet quality using a representative sample of US men and women. The current investigation found that BMI and waist circumference tended to be higher in the older cohorts of adults, which is supported by previous studies of weight status in adult populations (11,12,35). In distinct contrast, MVPA was strikingly lower in the older age groups for both men and women. In both genders, MVPA in adults ≥70 yr was only 20%–25% of that observed in the 20- to 29-yr age groups. Previous studies have documented similar differences in physical activity by age groupings (3,4). Interestingly, men and women reported higher diet quality in the older age groups. This same trend was observed in an earlier round of NHANES (16). These observations suggest that, at the population level, age-related increases in BMI and waist circumference are likely to be explained by the age-related decline in physical activity.

The present study stands alone as the first study to have examined the relations among physical activity, diet quality, and measures of weight status in nationally representative age/gender subgroups of US adults. Because of the cross-sectional study design, we were unable to determine directionality of these relations. However, the fact that these relations were studied across the adult lifespan in racially and ethnically diverse samples of men and women is a major strength of the study. Other strengths include use of an objective measure of physical activity and application of an accepted index of diet quality, although it is acknowledged that both measures have limitations. Accelerometry underdetects some forms of physical activity, and the index of diet quality is based on self-reported information. Furthermore, the physical activity measure used here does not measure energy expenditure, just as the diet quality index does not measure energy intake. We cannot exclude the possibility of selection bias given the number of participants excluded because of missingness in the objectively measured physical activity and 24-h dietary recall variables. Furthermore, the parameter estimates, although considered to be statistically significant, were small. Within the limitations of the study methodology, we conclude that higher levels of physical activity are very consistently associated with more favorable weight status in US adults. We believe that these findings provide support for public health efforts to prevent obesity by promoting increased physical activity in adult Americans.

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