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Obesity, Overweight, and Their Life Course Trajectories in Veterans and Non-Veterans

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Veterans comprise a large and growing segment of the US population. Results from national telephone surveys suggest higher prevalence of overweight among Veterans compared with demographically similar non-Veterans, based on self-reported height and weight. Using 1999–2008 data from the National Health and Nutrition Examination Survey (NHANES), we compared 3,768 Veterans and 21,974 non-Veterans on: (i) several measures of adiposity based on direct anthropometry; (ii) life-course of self-reported BMI; and (iii) behaviors related to weight loss or maintenance. Whether Veterans were more likely than demographically similar non-Veterans to be obese or overweight depended on the adiposity measure employed. On BMI, Veterans were about equally likely to be obese (30+ kg/m^2), but more likely to be overweight (25–29.9 kg/m^2) by both self-report and by direct measurement (significantly so only by self-report). On waist-stature ratio, a roughly similar pattern was observed. On waist circumference, Veterans tended to have larger values than demographically similar non-Veterans, with more Veterans in the largest two categories. But on dual-photon X-ray absorptiometry, Veterans were less likely to have 35+% body fat than non-Veterans of similar age, gender, and race/ethnicity. Life-course trends in self-reported BMI suggested a possible burst of weight gain after military discharge. These results suggest that Veterans may, on average, have less excess body fat than non-Veterans—a pattern not revealed by standard anthropometric measures.

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INTRODUCTION

Veterans of military service constitute a large and growing segment of the US adult population. The Department of Veterans Affairs (VA) estimated that there were 23.1 million Veterans in the United States in 2009, of whom 5.7 million used publicly funded VA health care at least once during the fiscal year (1).

Obesity and overweight might be expected *a priori* to be less common among Veterans than among non-Veterans. New recruits must pass medical evaluation to enter military service, which would screen out those with serious pre-existing obesity or obesity-related chronic conditions. Overweight and obesity at intake into the Air Force were indeed found to be less common than among respondents of similar age and gender in a large national survey (2). Physical fitness is mandated throughout a military career, and some evidence suggests that higher exercise levels are maintained after discharge from service (3). Tobacco smoking has also been found to be more common among Veterans than among non-Veterans (4) and might limit weight gain. Nonetheless, results from the Centers for Disease Control Behavioral Risk Factor Surveillance System (BRFSS), a large national telephone survey, suggested that Veterans were significantly more likely to be classified as overweight (BMI = 25–29.9 kg/m^2) but about equally likely to be classified as obese (BMI ≥ 30 kg/m^2) compared to non-Veterans of similar age and gender (5,6).

A concern about the higher prevalence of overweight in Veterans in BRFSS data is that it may be an artifact of measurement error. In telephone surveys, BMI must be based on self-reported height and weight. Validation studies have found that survey respondents generally tend to over-report their height and to under-report their weight (7,8). The extent to which reporting biases may vary in relation to demographic characteristics and Veteran status is unknown. In addition, some authors have questioned the validity of BMI itself as an indicator of obesity (9), especially in highly physically fit individuals, such as professional athletes (10,11). Compared with BMI, waist circumference has been found to be more strongly correlated with percent body fat as assessed by dual-energy X-ray absorptiometry (DXA) in males (12) and to be more strongly correlated with cardiovascular risk factors (13). Other authors have advocated use of the waist-to-height ratio as a simple measure of excess weight (14).

The present study sought to re-examine the association between Veteran status and overweight/obesity status, using

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data from the National Health and Nutrition Examination Survey (NHANES). NHANES collects data on weight, height, and other anthropometric measures by direct examination. In certain years, DXA-derived measures of percent body fat were also obtained. Thus, we retested the null hypothesis of no difference in the prevalence of obesity and overweight by Veteran status using other and arguably better measures of adiposity. Interview data with NHANES participants also permitted comparisons between Veterans and non-Veterans as to the life-course trajectory of adiposity, albeit based on self-report of weight and height at earlier ages. This information may shed light on how any differences in adiposity by Veteran status arise with age.

METHODS AND PROCEDURES

Sample

Data from the NHANES from 1999–2008 were combined for analysis. Details of the NHANES sample design and data collection methodology are available elsewhere (15). Briefly, NHANES seeks to identify a probability sample of civilian, noninstitutionalized US residents. Since 1999, data collection has been conducted every year. A multi-stage sampling design is used, involving stratification by geographic region, probability samples of primary sampling units (generally counties) within each region, census tracts within primary sampling units, dwelling units within census tracts, and finally individual respondents within dwelling units. The present analysis included 25,743 adults aged 21 years or older with known Veteran-status information.

Data

NHANES collected data both by direct in-person examination and by interviews with examinees. Height, weight, and waist circumference were assessed by direct measurement in all years, and self-reported height and weight were also obtained in all years. Those values were used to obtain several measures of adiposity: (i) BMI calculated as (weight in kilograms)/(height in meters)^2 using interview data; (ii) BMI calculated similarly by direct measurement; (iii) waist circumference by direct measurement, in centimeters; and (iv) waist-stature ratio by direct measurement, as (waist circumference in centimeters)/(height in meters). In addition, in 1999–2004, NHANES examinations included DXA, which yielded estimates of percent body fat for 13,182 examinees in those years. All of these measures have been used in epidemiologic studies to quantify the population frequency of excess body weight (12). Strictly speaking, only DXA provides a direct measure of body fatness or adiposity. The remaining measures are best regarded as yielding proxy indicators of adiposity, based on simpler and less costly anthropometric measurements. Data on key covariates including age, gender, race, and education, were obtained from interviews.

Analysis

Values for each measure were grouped into categories as shown in **Table 3**. For BMI, standard cutpoints appearing in the literature (e.g., (5,6,16)) were used. For waist circumference and waist-stature ratio, we chose gender-specific cutpoints based on work by Flegal *et al.* (12), using values that corresponded approximately to percent body fat of 25%, 30%, and 35%, respectively, for persons aged 20–39 years.

Because the distribution of sociodemographic factors proved to be quite different between Veterans and non-Veterans, we used model-based direct adjustment to control for potentially confounding factors (17). This method applies a regression-based weighting factor to the original NHANES sampling weight for each observation, based on its combination of covariate values. Summary statistics based on these augmented weights can be interpreted as estimates of the value expected in the group of interest if it had the same distribution of covariates as found in a reference population (here, all sampled Veterans).

To account for stratification and multi-stage sampling in NHANES, the svy survey data commands in Stata 11.0 were used for all analyses (Stata, College Station, TX). *P* values were based on Pearson's χ^2 statistic, corrected for the survey design and converted to an F-statistic (18). *P* values of <0.05 were considered statistically significant.

RESULTS

Table 1 compares the distribution of several sociodemographic characteristics between non-Veterans and Veterans in the study sample. Compared with non-Veterans, Veterans were generally older, were much more likely to be males, were predominantly non-Hispanic whites, and had generally higher educational attainment. A much larger percentage of Veterans were former smokers, but the prevalence of current smoking was similar.

Overall, about one-third of both Veterans and non-Veterans were classified as obese on the basis of having a directly measured BMI ≥ 30 kg/m^2 (**Table 2**). Fewer than 2% of either group were underweight (BMI < 18.5 kg/m^2). A larger proportion of Veterans were overweight, with a BMI from 25–29.9 kg/m^2 (42.6% vs. 33.1%). However, once BMI in non-Veterans was adjusted to the age, gender, and race/ethnicity distribution of Veterans, the two groups were similarly distributed among the BMI categories. Further adjustment for education (as categorized in **Table 1**) yielded only slight incremental differences.

Past published comparisons of excess weight between national samples of Veterans vs. demographically similar non-Veterans used BRFSS data (5,6) and were thus based on height and weight as self-reported in a telephone survey. To help isolate the influence of method of BMI measurement (based on self-reported vs. directly measured height and weight), **Table 3** compares BMI by both methods on NHANES participants. The distribution among obesity/overweight categories by directly measured BMI was shifted upward in relation to the BMI distribution by self-report in both Veterans and non-Veterans. By self-report, about 28–29% of both groups were classified as obese, while by direct measurement, about 32–33% of both groups were obese. Nonetheless, the prevalence of obesity was nearly equal between Veterans and non-Veterans classified by the same method. By either method, differences between Veterans and non-Veterans were largely confined to the normal and overweight categories: overweight was more common, and normal weight less common, in Veterans than in non-Veterans. This difference was statistically significant in the self-reported comparison, but not in the directly measured comparison.

Table 3 also compares Veterans and non-Veterans of similar age, gender, and race/ethnicity on other measures of adiposity. On waist circumference, the distribution in Veterans tended to be shifted toward larger values than in non-Veterans, with the largest excess prevalence in the next-to-highest category. On waist-stature ratio, which aims to correct waist circumference for height differences, the distribution among Veterans was more concentrated in the two middle categories, with proportionally fewer Veterans in the lowest and highest categories. On percent body fat as measured by DXA, the distribution among Veterans was even more concentrated in the two middle categories (25–34.9% body fat), with a notably smaller proportion of Veterans (20.6%) than non-Veterans (23.9%) in the most obese category (35+% body fat).

Table 4 shows results concerning possible differences in the trajectory of weight gain over the life course between Veterans and non-Veterans. Respondents in the interview part of NHANES were asked to recall their height and weight at age 25 years, which was then used to estimate BMI retrospectively at that age. The age-25 BMI for each participant was then compared to his/her BMI (from self-reported height and weight) at the time of the examination. Because the amount of time between age 25 and age at examination varied among the age strata, mean annual change in BMI was calculated to facilitate comparisons. For this analysis, only subjects aged 30 years or older at examination time were included, so that sufficient time had passed between age 25 and their current age. Three 15-year age groups were used to achieve a relatively even distribution of subjects among the groups. The mean rate of change in BMI was nearly identical between Veterans and non-Veterans among examinees aged 45–59 or 60–74 years at

Table 1 Demographic characteristics of NHANES sample (1999–2008) by Veteran status for adults age 21+ years

	Non-Veterans		Veterans	
Characteristic	%	*n*	%	*n*
Total *n*	100.0	21,974	100.0	3,768
Age (years)				
21–34	29.9	6,332	8.9	227
35–49	34.0	5,897	22.1	541
50–64	21.8	4,685	33.3	998
65–79	10.7	3,441	27.5	1,331
80+	3.7	1,630	8.3	671
Gender				
Male	40.8	8,728	93.4	3,562
Female	59.2	13,247	6.6	206
Race/ethnicity				
White, non-Hispanic	69.3	10,263	82.9	2,567
Black, non-Hispanic	11.2	4,419	9.7	728
Hispanic	13.9	6,383	4.6	393
Other	5.6	910	2.8	80
Education				
Less than high school	21.0	7,381	13.8	769
High school graduate	25.3	5,109	27.2	1,015
Some college	28.7	5,434	32.7	1,122
College graduate	25.0	4,004	26.3	859
Smoking status				
Never	53.5	12,112	33.3	1,233
Former	22.2	5,025	43.5	1,764
Current	24.3	4,811	23.2	768

Table 2 Directly measured BMI distribution (in %) among Veterans and non-Veterans, adjusted for selected combinations of sociodemographic characteristics

	Directly measured BMI (kg/m^2)				
	<18.5	18.5–24.9	25–29.9	30+	*P*
Veterans	1.0	23.6	42.6	32.8	
Non-Veterans, adjusted[a] for					
Nothing	1.9	32.7	33.1	32.3	<0.001
Age	1.6	30.5	34.3	33.6	<0.001
Age, gender	1.1	26.5	41.0	31.5	0.13
Age, gender, race/ethnicity	1.1	25.6	40.7	32.5	0.3
Age, gender, race/ethnicity, education	1.0	25.0	40.7	33.3	0.5

[a]Adjusted to distribution of covariates in Veterans.

Table 3 Comparison of selected measures of adiposity between Veterans and non-Veterans, adjusted for age, gender, and race/ethnicity

	Percent among:		
	Non-Veterans	Veterans	*P*
BMI (kg/m^2)			
By self-report	(*n* = 21,090)	(*n* = 3,738)	0.023
<18.5	0.8	0.5	
18.5–24.9	29.5	26.7	
25–29.9	41.0	44.3	
30+	28.7	28.5	
By direct measurement	(*n* = 20,109)	(*n* = 3,437)	0.3
<18.5	1.1	1.0	
18.5–24.9	25.6	23.6	
25–29.9	40.7	42.6	
30+	32.5	32.8	
Waist circumference (cm)[a]	(*n* = 19,565)	(*n* = 3,347)	0.056
Lowest	16.3	13.9	
Low	31.4	30.8	
High	28.9	31.1	
Highest	23.4	24.3	
Waist-stature ratio[b]	(*n* = 19,481)	(*n* = 3,325)	0.017
Lowest	16.7	14.1	
Low	30.5	31.5	
High	28.3	31.2	
Highest	24.5	23.3	
Percent body fat (by DXA)[c]	(*n* = 11,060)	(*n* = 2,122)	0.034
<25%	20.2	18.4	
25–29.9%	29.0	30.3	
30–34.9%	26.9	30.6	
35+%	23.9	20.6	

DXA, dual-energy X-ray absorptiometry.
[a]Cutpoints for males: 90, 102, 114 cm; for females: 69, 74, 81 cm. [b]Cutpoints for males: 51, 58, 65; for females: 42, 45, 49. [c]Available only for 1999–2004 survey years.

Table 4 Change over time in BMI between Veterans and non-Veterans, by age at examination, adjusted for gender and race/ethnicity

Age in years at examination		Mean ± s.d. Non-Veterans	Mean ± s.d. Veterans	*P*
30–44	BMI at age 25	24.8 ± 6.1	24.8 ± 3.4	0.9
	BMI at exam	28.4 ± 8.4	28.6 ± 4.5	0.6
	Annual change in BMI	0.28 ± 0.51	0.32 ± 0.32	0.045
45–59	BMI at age 25	24.2 ± 3.4	24.3 ± 3.0	0.6
	BMI at exam	28.9 ± 5.2	29.0 ± 4.5	0.8
	Annual change in BMI	0.18 ± 0.16	0.17 ± 0.17	0.9
60–74	BMI at age 25	23.9 ± 3.5	23.7 ± 3.6	0.3
	BMI at exam	29.1 ± 4.9	29.1 ± 5.9	1.0
	Annual change in BMI	0.13 ± 0.11	0.13 ± 0.13	0.4

Table 5 Weight-control behaviors reported used, by BMI category and Veteran status, adjusted for age, gender, and race/ethnicity

Behavior; BMI at examination	Percent reporting behavior among: Non-Veterans	Percent reporting behavior among: Veterans	*P*
Tried to lose weight in past year			
Normal weight (18.5–24.9)	10.2	9.9	0.9
Overweight (25–29.9)	27.9	30.6	0.094
Obese (30+)	47.6	47.4	0.9
Tried to maintain weight in past year			
Normal weight (18.5–24.9)	18.6	15.4	0.10
Overweight (25–29.9)	35.4	39.2	0.096
Obese (30+)	42.2	46.3	0.18
Sought weight loss help from health professional (among those trying to lose weight)			
Normal weight (18.5–24.9)	8.0	0.0	0.13
Overweight (25–29.9)	5.3	5.5	0.9
Obese (30+)	10.3	11.1	0.8

examination. However, in the youngest age group, the rate of increase in BMI was significantly greater among Veterans than among non-Veterans.

Lastly, **Table 5** addresses the frequency of self-reported weight-control behaviors among NHANES participants by BMI category, comparing Veterans and demographically similar non-Veterans. Overweight Veterans were 3–4 percentage points more likely to report trying to lose weight or maintain their weight, compared to overweight non-Veterans, although these differences were of only borderline statistical significance. Otherwise, the groups were similar.

DISCUSSION

To what extent are obesity and overweight more prevalent in US Veterans than in demographically similar non-Veterans? The answer to this question can help quantify the burden of obesity and obesity-related diseases on Veterans and on the publicly funded health care resources that they use. It may also contribute to judging the long-term impacts of health habits influenced by military service, including diet, exercise, and smoking. Because both body weight and percent body fat tend to be greater in older age groups in large national surveys (12,16) (particularly after accounting for birth-cohort effects), it was important to adjust for age differences between Veterans and non-Veterans.

We found that whether Veteran status is a risk factor for excess body weight depends to a large extent on how adiposity is measured and how "excess body weight" is defined. When assessed with BMI using directly measured height and weight, obesity defined as BMI ≥ 30 kg/m^2 was about equally prevalent in Veterans and non-Veterans after adjusting for differences in age, gender, and race/ethnicity. The prevalence of overweight defined as BMI 25–29.9 kg/m^2 was about two percentage points more common in Veterans than in demographically similar non-Veterans when based on directly measured height and weight, or about three percentage points more prevalent when based on self-reported height and weight. (Only by self-report was the difference statistically significant.) A roughly similar pattern was observed for waist-stature ratio which, like BMI, involves a simple correction for height. For waist circumference, the distribution among Veterans appeared to be shifted upward rather than being more concentrated in the middle of the distribution. Yet another answer was provided by percent body fat as assessed by DXA: Veterans were less likely to fall into the high-body-fat (35+%) or low-body-fat (<25%) categories and more likely to have 25–35% body fat by DXA, toward the middle of the population distribution.

The study also provided further evidence about bias in BMI when based on self-reported height and weight. In both Veterans and non-Veterans, BMI calculated from self-reported height and weight tended to be lower than BMI calculated from direct measurements. The prevalence of BMI-defined obesity (≥30 kg/m^2) was about four percentage points greater when based on directly measured height and weight than when based on self-reported height and weight in both groups. Smaller discrepancies in the prevalence of BMI-defined overweight (BMI 25–29.9 kg/m^2) were seen in both groups. Still, there was little evidence of any differential bias between Veterans and non-Veterans. This conclusion would lend support to previous comparative studies based on self-reported BMI (e.g., (4–6,19)) using much larger sample sizes.

However, the DXA comparisons in this study raise questions about the validity of BMI itself as an indicator of adiposity in Veterans. Judging by BMI, Veterans were equally likely to be obese and somewhat more likely to be overweight than demographically similar non-Veterans, whereas Veterans were found to be less likely to have high (35+%) body fat content on DXA scanning than demographically similar non-Veterans. These apparent discrepancies suggest that concerns expressed about the validity of BMI as an adiposity measure in physically fit individuals (10,11) may apply beyond just professional athletes and active-duty military personnel. Other authors (20) have questioned whether BMI controls adequately for stature—a relevant concern inasmuch as Veterans tended to be taller than non-Veterans of similar age, gender, and race/ethnicity in the NHANES sample (data not shown). Another possibility is that even though average percent body fat may be lower in Veterans, its anatomical distribution may differ, with more fat concentrated in the abdomen among Veterans.

Based on these findings, clinicians providing care to Veterans may want to use extra caution when interpreting BMI as an indicator of adiposity. BMI values just above 25 kg/m^2 in a physically fit Veteran may classify the individual as overweight, even though DXA would not reveal excess body fat.

In light of our results, descriptions of changes in adiposity over the life course would ideally be assessed by serial DXA scans for body-fat measurement on a panel of individuals as they aged. In the absence of such evidence, NHANES data do permit retrospective description of trends in adiposity over the life course based on self-reported BMI. We found that the rate of increase in BMI since age 25 years was significantly greater for Veterans aged 30–44 years at the time of NHANES participation than among comparably aged non-Veterans. With later age at examination, the Veteran/non-Veteran differences in rate of change of BMI disappeared. Although no information was available about the age at which each Veteran separated from military service, a typical pattern would involve a few years of active duty as a young adult, followed by a transition to Veteran status. Thus, a possible interpretation of these findings is that a “burst” of weight gain may occur in the first few years after separating from the military, followed by gradual convergence to the same pattern of weight gain with age seen in non-Veterans. This interpretation is consistent with recent findings from the Millennium Cohort Study, involving periodic surveys of a cohort of military personnel during and after active duty (21).

Although NHANES data have many strengths, several limitations of this study should be kept in mind. Although we combined data over a 10-year period, sample sizes remained modest in comparison to the much larger national telephone survey samples that have been used to compare Veterans and non-Veterans. Arguably the most accurate measure of adiposity, percent body fat based on DXA scanning, was part of the NHANES examination protocol only in certain survey years, resulting in further diminution of sample size. No details were available about the duration of active duty or timing of separation from military service. Previous studies based on BRFSS data have suggested important differences within Veterans according to whether they did or did not receive health care through the VA, which bears on the degree to which obesity poses a special burden to publicly financed care for Veterans. No data on VA health care use were available in NHANES.

Finally, we found a glimmer of hope in the comparison of self-reported weight-control behaviors among NHANES respondents. In comparison with non-Veterans in the same BMI category, overweight Veterans were somewhat more likely to report that they were trying to lose or maintain weight. Conceivably, military service may inculcate a leaner, fitter desirable body image that may persist into later life. If so, perhaps weight-control programs in Veterans may be able to capitalize on that difference in readiness to change when seeking to motivate healthy dietary and exercise behaviors.

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DISCLOSURE

The authors declared no conflict of interest.

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