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BMI trajectory groups in veterans of the Iraq and Afghanistan wars

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Abstract

Objective—The study sought to determine BMI trajectories in Iraq/Afghanistan veterans over 6 years and to examine sociodemographic factors associated with BMI trajectory membership.

Methods—Our study sample included 16,656 veterans post-deployment and entering the Veteran Healthcare Administration (VHA) healthcare system. We used national VHA administrative sociodemographic data, tracked veteran BMI for 6 years, and used trajectory modeling to identify BMI trajectories and sociodemographic characteristics associated with trajectory membership.

Results—Five trajectory groups determined in the full sample were primarily differentiated by their post-deployment initial BMI: “healthy” (14.1%), “overweight” (36.3%), “borderline obese” (27.9%), “obese” (15.7%), and “severely obese” (6.0). Being female, younger, and white were associated with lower initial BMI trajectory group membership ($p < .05$). Greater observed BMI increase was associated with higher initial BMI across groups (0.6, 0.8, 1.5, 1.9, 2.7). Gender specific trajectory models found that male Veterans with higher education and white female Veterans were associated with the lowest initial BMI group ($p < .05$).

Conclusions—Higher post-deployment BMI was associated with greater BMI gain over time for both male and female veterans. Older age is associated with higher BMI regardless of gender. Education level and racial status are differentially related to BMI trajectory by gender.

Keywords

Obesity; Overweight; OEF/OIF veterans; Trajectory modeling

Introduction

Obesity is recognized as an independent predictor of mortality (Calle et al., 1999; Adams et al., 2006), as well as a risk factor for other medical conditions, including congestive heart failure, cancer, osteoarthritis, obstructive sleep apnea, the metabolic syndrome, and diabetes (Kenchiah et al., 2002; Mokdad et al., 2004; Jee et al., 2006). The prevalence of obesity continues to be high in the United States, with recent estimates of 32.3% for men and 35.5%

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

for women in the general population (Flegal et al., 2010). Comparable rates of obesity have also been reported in the veteran population (Das et al., 2005; Wang et al., 2005; Nelson, 2006; Almond et al., 2008; Koepsell et al., 2009; Noel et al., 2010), although veterans may have a higher prevalence of overweight (Koepsell et al., 2009). Rates of obesity appear to be higher in veterans using Veterans Affairs (VA) medical facilities than veterans who do not use VA (Nelson, 2006; Koepsell et al., 2009). The projected prevalence of obesity-related illnesses and their resulting costs are predicted to be among the highest concerns for the Veterans Health Administration (VHA) in the near future.

The current wars in Afghanistan (Operation Enduring Freedom; OEF) and Iraq (Operation Iraqi Freedom; OIF) have brought a new wave of veterans who are seeking medical services at VA facilities. Younger in age, they may use VHA healthcare for decades to come. Early reports support that overweight/obesity is already a problem for this veteran group (VSSC data, 2008). Weight loss, however, also may be a concern for these newest veterans whose combat exposure has been associated with risk for developing eating problems and weight loss in OEF/OIF female veterans (Jacobson et al., 2009).

There are limited data on overweight/obesity prevalence in OEF/OIF veterans, and no information on initial body mass index (BMI) and subsequent BMI change following entry into the VHA healthcare system. The objectives of this study were to: 1) determine trajectories of BMI change over a six year period in a subset of OEF/OIF veterans, and 2) examine sociodemographic factors associated with BMI trajectory membership.

Materials and methods

Data sources and study population

The study participants were OEF/OIF veterans entering the VHA for health care following deployment. This sample was obtained from VHA's OEF/OIF roster provided by Defense Manpower Data Center – Contingency Tracking System. This roster included information on all personnel discharged from the U.S. military from October 1, 2001 through September 30, 2009 who enrolled for VHA healthcare or received VHA healthcare before January 31, 2010. This included a sample size of $n=373,295$. To obtain our study sample, starting from the date of the first VHA healthcare visit for each veteran, we calculated BMI at VHA visits within a six month time frame for up to 6 years. Thus, while all veterans had different actual starting dates, time in the study began for each veteran at their first VHA healthcare visit. Each veteran had at most 12 BMI observations. A missing BMI value was generated if weight was not recorded during a specific 6-month window. We limited our analytic sample to veterans who had at least seven observed BMI values after their last deployment end date. This restriction was necessary to collect sufficient and necessary information for determining the BMI trajectories. The final study sample included 16,656 Veterans.

Sociodemographic and clinical characteristics

Gender, age, race, height, weight, and deployment end date, and date of initial VHA encounter were obtained from VHA electronic medical record data. Height and weight data were taken from a same day encounter and were used to calculate the body mass index (BMI). Weight across encounters was used to calculate BMI at each following visit. BMI 25 was regarded as overweight, and BMI 30 as obese. The number of months between end of deployment and initial visit was calculated as an adjustment factor.

Analysis

To test for demographic differences between male and female veterans we used chi-square test for race and education, and *t*-test for age and the number of months between deployment and entry to the VHA healthcare system.

To identify clinically distinct trajectories of BMI, we used latent class trajectory modeling with a censored normal distribution. This allowed us to estimate multiple underlying BMI trajectories rather than a single intercept and slope for the whole sample. This method tests whether the sample is composed of a mixture of different subpopulations that can be defined by their trajectories across time. We used a customized SAS 9.2 procedure (PROC TRAJ) developed by Jones et al. (2001); Jones and Nagin, 2007). With this procedure, each veteran is assigned a probability of being on a given trajectory.

Most experts (D'Unger et al., 1998; Roeder et al., 1999; Keribin, 2000; White et al., 2002; Ostbye et al., 2011) suggested that both conceptual considerations and empirical criteria (e.g., Bayesian Information Criterion) should be used to determine the optimal number of subpopulations within the data. Thus, we first examined both the Bayesian Information Criteria for the goodness of fit of the whole model and *t* statistics for the significance of each parameter (including linear, quadratic, and cubic terms of the trajectory models) using different numbers of trajectories. Furthermore, we considered the generality and parsimony of the representation for characteristics of data to determine the best number of BMI trajectories that fit our data. Veterans were assigned to a specific BMI trajectory based on the maximum estimated probability of membership. A probability of 0.9 or higher is considered an excellent fit, while a value less than 0.7 is considered a poor fit (Nagin, 2005). This analytic procedure was repeated to analyze the latent BMI trajectory by gender. Two-sided *t*-tests for parameter were considered significant when the *P* value was <.05.

Results

The demographic characteristics of both the OEF/OIF veteran study sample and full sample are displayed in Table 1. Of the study sample, 65.8% of the male and 46.7% of the female veterans were overweight or obese as defined by BMI at their first VHA visit. Male veterans were significantly older than female veterans, and were more likely to be white and less educated. Compared to the full sample, the study sample was more likely to be female, non-white, more educated, and have fewer months between deployment and VA entry.

Using the analytic procedures described above, we compared models based on four to seven groups. The five BMI trajectory group model for the full study sample provided the best solution and is displayed in Fig. 1. The five groups were notably different in their observed initial BMI and were labeled as follows: Group 1; "Healthy", initial BMI=21.9 (14.1% of cohort), Group 2; "Overweight", initial BMI=26.1 (36.3% of cohort), Group 3; "Borderline obese", initial BMI=29.7 (27.9% of cohort), Group 4; "Obese", initial BMI=33.2 (15.7% of cohort), and Group 5; "Severely Obese", initial BMI=38 (6.0% of cohort). Veterans' BMI trajectories had excellent fit where 88.1% to 94.8% of the veterans had a mean probability of membership of 0.9 or higher, and where 0.7% to 3.2% of the veterans had a probability of their assigned trajectory less than 0.7. The five trajectories had different slopes and curvatures and the quadratic term was significant for all trajectory groups. Notably, BMI changes of the Healthy and Overweight groups (the two groups with lowest initial BMI) had the least BMI change over time (observed BMI increases of 0.6 and 0.8, respectively). The remaining three groups were characterized by trajectories with greater BMI fluctuations and greater BMI change over time (observed BMI increases of 1.5, 1.9, and 2.7, respectively). There were no trajectories characterized by overall weight loss.

Gender, age, and race were significantly associated with trajectory group membership ($p < .05$) in the veteran cohort. The Healthy BMI group included more women, younger veterans, and white veterans. Because gender differences in trajectory group membership were found in the full sample model, gender specific trajectory analyses were conducted. Using the same analytic procedures, trajectory models with five groups were additionally chosen for the male and female veteran samples. The demographic characteristics by trajectory group for all three trajectory solutions are displayed in Table 2. Gender specific trajectories are displayed in Figs. 2 and 3. These trajectories also showed excellent fit, with 86% to 95.7% of women and 90.1% to 95.9% of men having mean probability of membership of 0.9 or higher. The quadratic terms for all male groups were significant. Observed increases in BMI change for the men's trajectory groups were 0.7, 0.7, 1.4, 1.7, and 2.8, respectively. The initial BMI's of all five female trajectory groups were significantly lower than the male groups' ($p < .001$ for all 5 trajectory groups), and were re-named as appropriate. In particular, the first two female trajectory groups had initial BMI's < 25 and were re-named "Healthy Slim" and "Healthy". These two groups had no significant changes in BMI across the 6 years. In contrast, the higher BMI female trajectory groups differed the most in slope and curvature, displaying more pronounced fluctuation and BMI increase over time. The quadratic terms were significant for the third and fourth groups, and the linear term was significant for the fifth group (i.e., highest initial BMI). Observed increases in BMI change for the women's trajectory groups were 0.5, 0.7, 2.1, 2.7, and 4.8, respectively. In the gender specific models, the lowest initial BMI group was associated with white racial status in females (all p 's $< .05$). Greater than high school education was generally associated with the lowest initial BMI group in male veterans (groups 2–4, p 's $< .05$).

Discussion

Our results support a high prevalence of overweight/obesity in OEF/OIF Veterans at their initial VHA encounter. Further, our trajectory analyses revealed five trajectories differing in initial BMI and in changes over time. The minority of veterans who enter VHA at a healthy BMI were able to successfully maintain healthy BMI over time. Veterans who enter VHA with higher initial BMI were more likely to have greater weight fluctuations over time and gain more weight over the first 6 years of VHA involvement. The BMI change is most dramatic in the trajectory group with the highest initial BMI—over the six year span, this group moved from an initial observed BMI of 38 to an end BMI of 40.7 at the end of 6 years. It appears that maintaining a stable BMI over time is less common for veterans who are already obese or severely obese, and that weight gain over time is more characteristic.

Older veterans, regardless of gender, are more likely to be overweight or obese. This is consistent with overweight/obesity trends for U.S. adults (Flegal et al., 2010). Nevertheless, OIF/OEF veterans are the youngest veteran group now entering the VHA healthcare system. Given the prevalence of overweight/obesity in this veteran group and the risk for medical comorbidities associated with obesity, efforts toward successful prevention and treatment of obesity should be a priority.

The risk for overweight/obesity is higher for male veterans at entry into VHA.

Female veterans are more likely to enter the VHA system at a healthy weight and to maintain the healthy weight during the early years of their veteran status. Gender differences in initial BMI at entry into VHA could be explained by several factors. First, because women are more vulnerable to height/weight discrimination than men (Puhl et al., 2008), female military personnel may be more focused on their weight maintenance efforts both during active duty and following deployment. Second, overweight/obese men are less likely to perceive excess weight as a health risk than women, and this perception is associated with

a lower prevalence of weight loss attempts. (Gregory et al., 2008). This suggests that male veterans might be less motivated to lose weight or maintain healthy weights. Third, gender differences in deployment experiences including reaction to trauma might influence weight (Jacobson et al., 2009).

Non-white female veterans and male veterans with less education were more likely to be associated with overweight and obese trajectory groups. The gender–race–education differences in overweight/obesity found in the present study are similar to a study of racial/ethnic differences in weight perception (Dorsey et al., 2009). The authors reported that among overweight/obese men, non-Hispanic blacks and those with a lower level of education, the odds were significantly greater to misperceive themselves as the “right” weight. In contrast, among overweight/obese women, the odds of misperception were higher for non-Hispanic black and Mexican Americans, as well as lower levels of education. Consideration of these findings supports that gender, educational level, and racial/ethnic background are not only risk factors for overweight/obesity, but that weight misperception may play a significant role in this process. Accounting for weight misperception may be an important component in weight management interventions.

To our knowledge, trajectory modeling has not been previously conducted on longitudinal BMI data in veteran populations. Our findings confirm that those who enter VHA at risk for developing obesity-related comorbidities because of high initial BMI do not reduce risk through sustained weight loss over time. Their weight may fluctuate more over time, and they are likely to continue to gain weight. This indicates that weight loss and/or maintenance interventions should be targeted and available for veterans as soon as they enter VHA to prevent weight gain and development of weight-related health challenges. These interventions may include a psychoeducational component that reviews weight misperceptions and provides information about health risks associated with overweight/obesity, in addition to information on promoting healthy eating and physical activity.

Limitations and strengths

Our study data is limited to OEF/OIF veterans who entered the VHA system post deployment. Our findings may not be representative of all OEF/OIF veterans. Comparison of the study sample with the full sample revealed that the study sample included more women, was slightly more racially diverse, and was more educated. These demographic differences may limit generalizability of study findings.

A major strength of our study is that the sample includes the newest wave of veterans accessing VHA healthcare at the point of their entry into the VA system. These veterans may seek care at VHA for the next 50 years. The longitudinal data allowed us to determine not only initial BMI, but tracked BMI for 6 years to examine post-deployment changes in BMI. Finally, use of trajectory modeling allowed us to identify patterns of BMI change in the years immediately post-deployment. In conclusion, our data support that BMI trajectories following deployment can be identified and associated with sociodemographic characteristics.

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BMI change trajectory group	BMI intercept Estimate (s.e.)	Linear term (s.e.)	Quadratic term (s.e.)
Healthy	22.1	-0.06 (0.023)	0.06 (0.002)
Overweight	26.4	-0.03 (0.014)	0.01 (0.001)
Borderline Obese	30.2	-0.01 (0.016)	0.01 (0.001)
Obese	33.9	0.01 (0.021)	0.01 (0.002)
Severely Obese	38.9	0.01 (0.0350)	0.01 (0.003)

Fig. 1. Trajectory solution of full veteran study sample from VHA roster of OEF/OIF veterans enrolled in VHA healthcare October 2001–January 2010 (n=16,656).

BMI change trajectory group	BMI intercept Estimate (s.e.)	Linear term (s.e.)	Quadratic term (s.e.)
Healthy	22.4 (0.084)	-0.08 (0.027)	0.01 (0.002)
Overweight	26.6 (0.047)	-0.04 (0.015)	0.01 (0.001)
Borderline Obese	30.4 (0.050)	0.00 (0.016)	0.01 (0.001)
Obese	34.3 (0.068)	0.01 (0.021)	0.01 (0.002)
Severely Obese	39.6 (0.130)	0.05 (0.042)	0.01 (0.003)

Fig. 2.

Trajectory solution of male veteran sample from VHA roster of OEF/OIF Veterans enrolled in VHA healthcare October 2001–January 2010 (n=13926).

BMI change trajectory group	BMI intercept Estimate (s.e.)	Linear term (s.e.)	Quadratic term (s.e.)
Healthy slim	21.3 (0.150)	-0.03 (0.048)	0.00 (0.003)
Healthy	24.7 (0.131)	0.01 (0.042)	0.00 (0.003)
Overweight	28.1 (0.135)	-0.02 (0.043)	0.01 (0.003)
Obese	31.8 (0.155)	0.01 (0.049)	0.01 (0.004)
Severely Obese	36.7 (0.253)	0.22 (0.08)	-0.00 (0.006)

Fig. 3.

Trajectory solution of female veteran sample from VHA roster of OEF/OIF veterans enrolled in VHA healthcare October 2001–January 2010 (n=2730).

Table 1

Demographics by gender of OEF/OIF veteran study sample and full sample from VHA roster of OEF/OIF veterans enrolled in VHA healthcare October 2001–January 2010.

Trajectory subsample	n=16,656	<u>Female</u>	<u>Male</u>	P value
		n=2730	n=13926	
Age (mean, SD)		31.3 (9.2)	34.8 (10.5)	p<0.001
Race (%)				p<0.001
Black		35.7	19.1	
Hispanic		12.2	13.7	
White		46.3	62.2	
Other/unknown		5.9	5.0	
Education (%)				p<0.001
High school or less		74.3	79.0	
Beyond high school		25.7	21.0	
Months between deployment and VA entry		12.4 (7.3)	12.3 (7.5)	p=0.893
Full sample	n=373,295	<u>Female</u>	<u>Male</u>	P value
		n=45,723	n=327,572	
Age (mean, SD)		28.8 (8.6)	30.2 (9.4)	p<.001
Race (%)				p<.001
Black		29.3	14.3	
Hispanic		10.6	11.3	
White		50.7	65.3	
Other/unknown		9.4	9.1	
Education (%)				p<.001
High school graduate or less		75.0	80.5	
Greater than high school		25.0	19.5	
Months between deployment and VA entry		19.8 (17.6)	19.2 (17.1)	p<.001

Characteristics by BMI trajectories identified in study sample from VHA roster of OEF/OIF veterans enrolled in VHA healthcare October 2001–January 2010.

Table 2

Study sample (n=16656)						
	<u>Trajectory 1</u>	<u>Trajectory 2</u>	<u>Trajectory 3</u>	<u>Trajectory 4</u>	<u>Trajectory 5</u>	P Value
	Healthy	Overweight	Borderline obese	Obese	Severely obese	
Trajectory size	2341 (14)	6085 (36)	4645 (28)	2579 (16)	1006 (6)	p<0.001
Age (mean, SD)	27.8 (9.2)	32.8 (10.7)	35.1 (10.5)	35.3 (10.0)	33.9 (9.4)	p<0.001
Female (n, %)	717 (30.6)	1001 (16.5)	593 (12.8)	283 (11.0)	136 (13.5)	p<0.001
White (n, %)	1482 (63.4)	3650 (60.0)	2714 (58.4)	1487 (57.7)	594 (59.0)	p<0.001
High school education or less (n, %)	307 (13.1)	1394 (22.9)	1098 (23.6)	634 (24.6)	192 (19.1)	p<0.001
Male only sample (n=13926)						
	<u>Trajectory 1</u>	<u>Trajectory 2</u>	<u>Trajectory 3</u>	<u>Trajectory 4</u>	<u>Trajectory 5</u>	P Value
	Healthy	Overweight	Borderline obese	Obese	Severely obese	
Trajectory size	1698 (12)	5125 (37)	4065 (29)	2387 (17)	652 (5)	p<0.001
Age (Mean, SD)	28.2 (9.7)	33.4 (10.9)	35.6 (10.5)	35.4 (10.1)	33.8 (9.3)	p<0.001
White (n, %)	1131 (66.8)	3208 (62.8)	2497 (61.4)	1418 (59.4)	409 (62.7)	p<0.001
High school education (n, %)	182 (10.7)	1128 (22.0)	925 (22.8)	576 (24.1)	114 (17.5)	p<0.001
Female only sample (n=2730)						
	<u>Trajectory 1</u>	<u>Trajectory 2</u>	<u>Trajectory 3</u>	<u>Trajectory 4</u>	<u>Trajectory 5</u>	P Value
	Healthy slim	Healthy	Overweight	Obese	Severely obese	
Trajectory size (n, %)	572 (22)	755 (28)	686 (25)	509 (19)	208 (7)	p<0.001
Age (mean, SD)	26.8 (8.1)	29.3 (8.6)	31.4 (9.6)	33.1 (9.6)	32.1 (9.0)	p<0.001
White (n, %)	321 (56.1)	361 (47.1)	300 (43.7)	190 (37.3)	91 (43.8)	p<0.001
High school education (n, %)	107 (18.7)	195 (25.8)	204 (29.7)	148 (29.1)	46 (22.1)	p<0.001