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SHORT COMMUNICATION

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Association of deployment with maintenance of healthy weight among active duty service members in the Millennium Cohort Study

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Abstract

Objective: Understanding body size in relation to deployment readiness can inform Department of Defense fitness policies. This study examined longitudinal associations between deployment and changes in body mass index (BMI) among active duty service members.

Methods: Service branch-specific changes in BMI post-deployment were examined using logistic regression models among active duty Millennium Cohort Study participants without obesity at baseline (n = 22,995). BMI was categorized using self-reported height and weight as healthy weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30 kg/m^2). Number of deployments between baseline and follow-up and initial deployment lengths (in months, using service branch-specific deployment times) were examined.

Results: Among the pooled population and specifically Army and Marine Corps service members without obesity, those with longer deployments were significantly less likely to maintain a non-obese BMI than those deploying for shorter lengths. Each additional deployment increased the likelihood of maintaining a non-obese BMI post-deployment for personnel in the Army, Marine Corps, and within the pooled population.

Conclusions: Multiple deployments may support healthy weight maintenance; longer deployments may adversely impact weight maintenance. Future research should determine modifiable behaviors related to weight gain post-deployment to inform fitness policies designed to optimize service member readiness and deployability.

KEYWORDS
body mass index, obesity, weight maintenance

1 | INTRODUCTION

Adherence to the Department of Defense's physical fitness policies is necessary to optimize service member readiness and deployability. While physical fitness requirements vary across service branch, one common element is meeting a specified threshold for weight and body mass index (BMI). Despite the fact that rates of obesity in the United States (US) military are lower overall than those observed in the general population,[1] research from the Millennium Cohort Study has shown that the prevalence of obesity doubled among service members over a 7-year follow-up period, increasing from 10% in 2001 to 20% in 2008.[2] Recent estimates suggest that 63.5% of US service members were classified as either overweight or obese in 2018.[1] Understanding factors related to increasing trends in overweight and obesity among military personnel are important for identifying potential health risks among service members, as having obesity is associated with increased risk for cardiovascular disease, diabetes, and certain cancers,[3] as well as excess mortality due to cardiovascular disease and obesity-related cancers.[4] Among service members specifically, obesity has been observed to be associated with physical and mental health comorbidities, such as hypertension, diabetes, sleep apnea, coronary heart disease, posttraumatic stress disorder, depression, and multiple somatic symptoms.[2] Similarly, comorbid medical conditions (such as high cholesterol, high blood pressure, diabetes, and sleep apnea) and joint and back disorders were recorded during nearly a quarter of medical encounters for clinical overweight or obesity among US military personnel serving in the active component between 1998 and 2010,[5] and it has been estimated that the Department of Defense (DoD) spends $1.1 billion per year on medical care costs associated with excess weight and obesity.[6]

In addition to the potential health consequences obesity may impose on service members, meeting weight standards is a critical element of military service since maintaining a healthy weight is imperative for carrying out certain military duties. In fact, service members who are unable to meet weight standards are either required to participate in a weight control program or may be discharged from service, since this indicates unsatisfactory levels of readiness.[7] For example, in 2008, more than 4,500 active duty service members were discharged early due to a failure to meet weight standards,[8] incurring significant monetary costs to the DoD related to recruitment and training, as well as a loss of force strength.[9] Given the often physically rigorous demands experienced in a deployed environment, such as walking and/or running long distances and carrying heavy packs, having a healthy weight is even more important to the safety and operational success of service members. Little research exists on the deployability of overweight or obese service members because in general, the most fit and healthy service members are the ones who deploy.[10,11] However, there is mounting evidence that BMI may not accurately predict a service member's ability to perform military-specific physical tasks.[12] Further, optimal performance may not align with the most strict body fat requirements.[7] While some studies have shown service members with the highest BMIs have the greatest risks for injury,[13] a 2017 study by Jones et al. showed that service members with the lowest BMI were at greatest risk for injury, regardless of their aerobic fitness level.[14] Furthermore, another 2017 study concluded that "older age and poor aerobic fitness are stronger predictors of injury than BMI".[15] However, BMI remains an easy, efficient, and cost-effective method for approximating a service member's level of body fat.

Taken together, lower levels of fitness, higher rates of injuries due to elevated BMI, and failure to meet body fat standards leading to disability among recruits undermine force readiness.[16–18] Although service members must qualify as fit prior to deployment, there are factors during deployment, such as access to food, stressors, and unhealthy sleep patterns, that may influence one's ability to maintain a healthy weight and which may be exacerbated to a greater extent during longer deployments.[19] In addition, there is very little research examining the effects of multiple deployments on healthy weight maintenance. A 2011 study by Macera et al. indicated that a short duration between two deployments was associated with increased weight after deployment,[19] but it remains unclear whether weight maintenance is affected by deploying multiple times over an extended period of time. Thus, understanding the relationship between body size and deployment will be instrumental in the examination and potential revision of physical fitness requirements. The goal of this study was to examine the relationship between deployment and subsequent change in BMI among active duty participants enrolled in the Millennium Cohort Study.

2 | METHODS

2.1 | Study population

The Millennium Cohort Study is the largest and longest running longitudinal epidemiologic study in the DoD that was designed to track service members throughout their military careers and beyond.[20] Participants complete follow-up surveys every 3 to 5 years following enrollment, with cumulative follow-up times for participants ranging from 3 to 12 years. With over 200,000 participants enrolled between 2001 and 2013 in four separate panels representing all service branches (Army, Navy/Coast Guard, Marine Corps, and Air Force), nearly half of whom have deployed in support of the operations in Iraq and Afghanistan, this study is uniquely positioned to examine deployment characteristics in relation to the development of obesity.

Participants were drawn from active duty Millennium Cohort Study participants from the first four enrollment panels who had no more than 5 years of service prior to enrollment (baseline) in the study, had at least one deployment in support of the operations in Iraq and Afghanistan between baseline and follow-up surveys, did not separate from service prior to follow-up, had a healthy weight or overweight BMI at baseline ($\geq$18.5 kg/m^2 and <30 kg/m^2), and had a recorded BMI at follow-up after return from deployment, resulting in a final analytic sample of 22,995 participants.

Participants provided written or electronic informed consent. The study protocol was approved by the Naval Health Research Center Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects. Research data were derived from an approved Naval Health Research Center, Institutional Review Board protocol number NHRC.2000.0007.

2.2 | BMI assessment

Pre-deployment BMI at baseline and BMI at follow-up after deployment were calculated using participants' self-reported height and weight and classified as healthy weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30 kg/m^2). At follow-up, underweight participants (<18.5 kg/m^2) represented 0.2% of the population and were combined with the healthy weight category.

2.3 | Deployment assessment

Deployment dates were ascertained from Defense Manpower Data Center electronic military records. Because deployment lengths vary by service branch, the average length of the first deployment between baseline and follow-up was defined as 9 months for Army, 6 months for Navy/Coast Guard, 8 months for Marine Corps, and 4 months for Air Force,[21] and categorized as deploying for at or above the branch-specific average number of months versus deploying for less than the branch average. The number of deployments between baseline and follow-up were examined as a continuous variable, ranging from 1 to 42 deployments.

2.4 | Analyses

Among those without obesity at baseline (i.e., those with a healthy weight or overweight BMI), separate logistic regression models estimated the likelihood of maintaining a non-obese BMI versus developing obesity in relation to the branch average length of deployment and the number of deployments following baseline. To assess the likelihood of obesity soon after return from deployment, sensitivity analyses were conducted that were restricted to 5,188 participants who completed follow-up surveys within 1 year after deployment.

Analyses were pooled as well as stratified by service branch, and adjusted for all covariates (enrollment panel, age, sex, race/ethnicity, marital status, pay grade, education level, occupation), the number of deployments before baseline, and the total length of time between the baseline BMI measurement and the post-deployment follow-up BMI measurement. All analyses were conducted in SAS (Version 9.2, Cary, NC); p-value <0.05 was considered statistically significant.

3 | RESULTS

Baseline characteristics of the sample are listed in Table 1. The average length of time between baseline and follow-up was 4.6 years (SD: 2.3) among participants. Overall, a majority of participants (≥88.2%) maintained a non-obese BMI between baseline and follow-up, with the mean change in BMI between baseline and follow-up being less than 1.5 kg/m^2 for all service branches.

Figure 1 displays adjusted odds ratios (AORs) and 95% confidence intervals (CIs) for maintaining a non-obese BMI among service members who had a deployment length at or above the branch average compared with those who deployed for less than the branch average. Army and Marine Corps service members were significantly less likely to maintain a non-obese BMI following a deployment that was at or above the average length for their branch compared with those who deployed for less time than the average, with similar trends among Navy/Coast Guard and Air Force personnel. In the pooled population, participants who deployed at or above the branch average length were significantly less likely to maintain a non-obese BMI compared with participants who deployed for less than the average length. Among the subset of personnel whose post-deployment follow-up was within 1 year of their last deployment (results not shown), an increased risk of obesity was observed only among Army personnel with a deployment length at or above the branch average (AOR = 0.63, 95% CI: 0.45–0.89). AORs for maintaining a non-obese BMI by mutually-adjusted relevant demographic and military covariates in models examining deployment length are listed in Table S1.

AORs for maintaining a non-obese BMI with each additional deployment between baseline and follow-up among service members are listed in Figure 2. Army and Marine Corps personnel were increasingly more likely to maintain a non-obese BMI with each additional deployment between baseline and follow-up, with a similar trend among Navy/Coast Guard and Air Force personnel. In the pooled population, service members were significantly more likely to maintain a non-obese BMI with each additional deployment. Among the subset of personnel whose post-deployment follow-up was within 1 year of their last deployment (results not shown), service members in the Army (AOR = 1.32, 95% CI: 1.13–1.54) and the pooled population (AOR = 1.12, 95% CI: 1.04–1.21) were increasingly more likely to maintain a non-obese BMI with each additional deployment. AORs for maintaining a non-obese BMI by mutually-adjusted relevant demographic and military covariates in models examining the number of deployments are listed in Table S2.

4 | DISCUSSION

This study examined the likelihood of maintaining a non-obese BMI following deployment as a function of deployment length and frequency. Personnel were less likely to maintain a non-obese weight if they experienced a deployment that was at or above the branch average in length. This may indicate that longer deployments

TABLE 1 Baseline characteristics of active duty service members with a healthy weight or overweight BMI by service branch (N = 22,995)

	Army (n = 8192) n (%)	Navy (n = 3634) n (%)	Marine Corps (n = 1869) n (%)	Air Force (n = 9300) n (%)
BMI category at baseline				
Healthy weight (18.5–24.9 kg/m^2)	3902 (47.6)	1805 (49.7)	918 (49.1)	5018 (54.0)
Overweight (25.0–29.9 kg/m^2)	4290 (52.4)	1829 (50.3)	951 (50.9)	4282 (46.0)
Change in BMI category from baseline to follow-up				
Maintained non-obese BMI (<30 kg/m^2)	7228 (88.2)	3263 (89.8)	1782 (95.4)	8539 (91.8)
Developed obesity (≥30 kg/m^2)	964 (11.8)	371 (10.2)	87 (4.7)	761 (8.2)
Number of deployments from baseline to follow-up				
Mean (SD)	2.1 (1.4)	2.3 (1.5)	1.8 (1.1)	3.3 (2.6)
Average length of deployment from baseline to follow-up				
Less than branch average length	3724 (45.5)	2031 (55.9)	1522 (81.4)	5471 (58.8)
At or above branch average length	4468 (55.5)	1603 (44.1)	347 (18.6)	3829 (41.2)
Age				
<25 years	3492 (42.6)	1742 (47.9)	1042 (55.8)	4478 (48.2)
25 years or older	4700 (55.4)	1892 (52.1)	827 (44.3)	4822 (51.9)
Sex				
Male	6179 (75.4)	2576 (70.9)	1688 (90.3)	6451 (69.4)
Female	2013 (24.6)	1058 (29.1)	181 (9.7)	2849 (30.6)
Race/Ethnicity				
White, non-Hispanic	5755 (70.3)	2276 (62.6)	1466 (78.4)	7258 (78.0)
Black, non-Hispanic	1070 (13.1)	414 (11.4)	119 (6.4)	931 (10.0)
Other	1367 (16.7)	944 (26.0)	284 (15.2)	1111 (12.0)
Paygrade				
Enlisted	6464 (78.9)	2885 (79.4)	1406 (75.2)	7252 (78.0)
Officer	1728 (21.1)	749 (20.6)	463 (24.8)	2048 (22.0)
Occupation				
Combat specialist	2086 (25.5)	632 (17.4)	454 (24.3)	1358 (14.6)
Health care	919 (11.2)	399 (11.0)	0 (0)	703 (7.6)
Functional support	1186 (14.5)	418 (11.5)	296 (15.8)	1468 (15.8)
Other	4001 (48.8)	2185 (60.1)	1119 (59.9)	5771 (62.1)
Marital status				
Single	2848 (34.8)	1670 (46.0)	803 (43.0)	3696 (39.7)
Currently married	4613 (56.3)	1698 (46.7)	978 (52.3)	4907 (52.8)
No longer married	731 (8.9)	266 (7.3)	88 (4.7)	697 (7.5)
Educational status				
Less than college degree	5909 (72.1)	2705 (74.4)	1377 (73.7)	6931 (74.5)
Bachelor's degree or higher	2283 (27.9)	929 (25.6)	492 (26.3)	2369 (25.5)
Enrollment panel				
1 (2001–2003)	2769 (33.8)	1092 (30.1)	461 (24.7)	2058 (22.1)
2 (2004–2006)	1829 (22.3)	727 (20.0)	306 (16.4)	1847 (19.9)

TABLE 1 (Continued)

	Army (*n* = 8192) *n* (%)	Navy (*n* = 3634) *n* (%)	Marine Corps (*n* = 1869) *n* (%)	Air Force (*n* = 9300) *n* (%)
3 (2007–2008)	2383 (29.1)	1220 (33.6)	900 (48.2)	3113 (33.5)
4 (2011–2013)	1211 (14.8)	595 (16.4)	202 (10.8)	2282 (24.5)

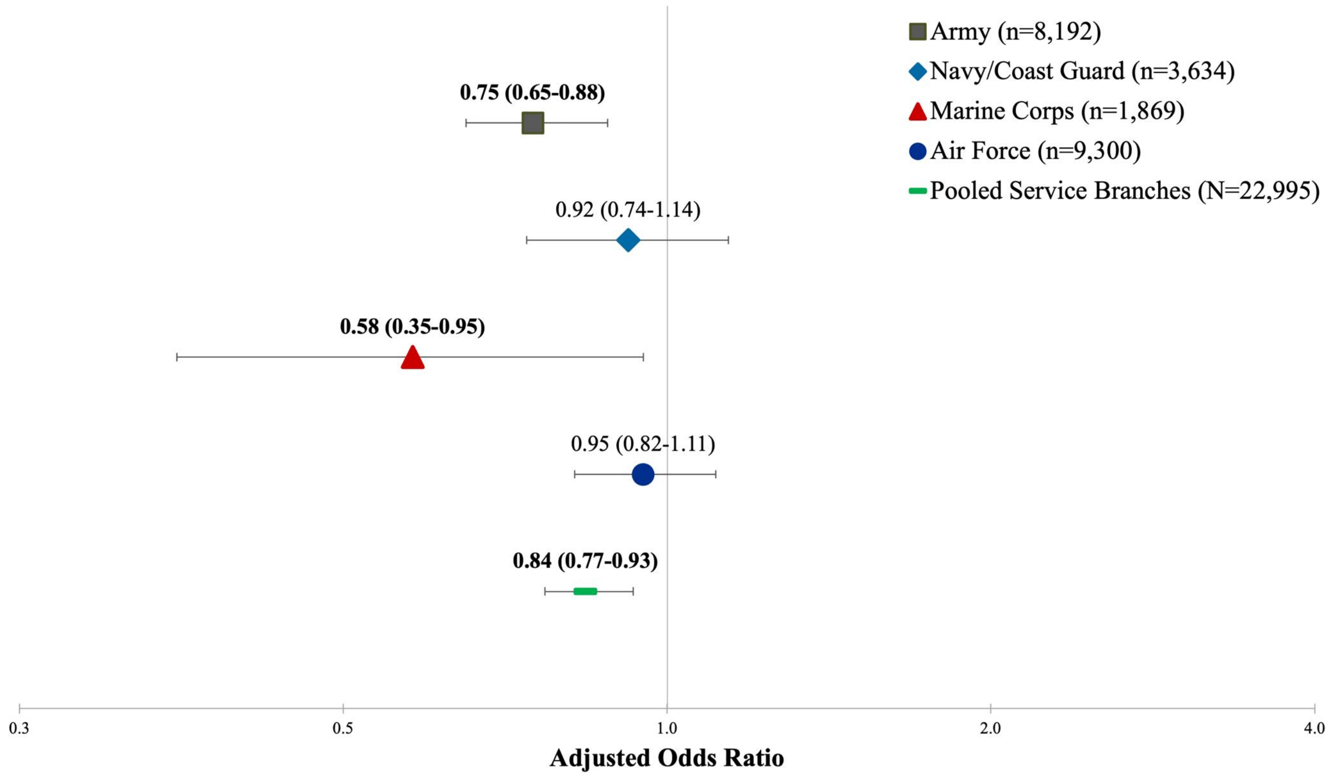

FIGURE 1 Adjusted odds ratios (95% confidence interval) of maintaining a non-obese Body Mass Index versus developing obesity following deployment with a length at or above branch average (reference = below branch average). Adjusted for all covariates, the number of deployments before baseline, and time between baseline and follow-up surveys. Bolded values are statistically significant ($p < 0.05$)

adversely impact the maintenance of a healthy weight. Longer deployments may hinder regular exercise routines or eating practices and might also provide an extended opportunity for eating larger amounts of food under stressful conditions, which in combination with stressful experiences and sleep difficulties that present during deployment,[22] may contribute to weight gain during this time.

Conversely, each additional deployment between baseline and follow-up increased the likelihood of personnel maintaining a non-obese BMI post-deployment. These findings suggest that those who maintain a healthier weight status in general could potentially be more primed and available for multiple deployments, while preparation for additional deployments may motivate service members to maintain a healthy weight. However, these findings were somewhat unexpected given that a large number of deployments may lead to the same vulnerabilities that interrupt normal exercise, eating, and sleep patterns as longer deployments. Additionally, frequent deployments may be particularly stressful for certain service member populations, such as those with spouses and families from whom they are separated during deployments. However, in all adjusted models, maintenance of a healthy weight was not significantly associated with marital status. Measures of relevant health behaviors, such as physical activity and sleep duration, were also examined in initial analytic models but were eliminated from the final models because they did not change the magnitude of effect estimates by more than 5%. While it is true that a large number of deployments may create additional and undue stress, in this study, the average number of deployments among those who deployed more than once was 3.4 (SD: 2.1), with a median of three deployments. It is possible that personnel in this population may not have deployed frequently enough to experience deployment-related stressors such as interrupted daily routines and separation from family that could impact weight maintenance in the same manner as longer deployments. Thus, in the present study, the theory holds that those called up to deploy multiple times represent individuals that may indeed be the most fit and ready for deployment missions. This fitness for service is analogous to the healthy warrior effect where service members are often healthier than their civilian counterparts.[10,11] Additional

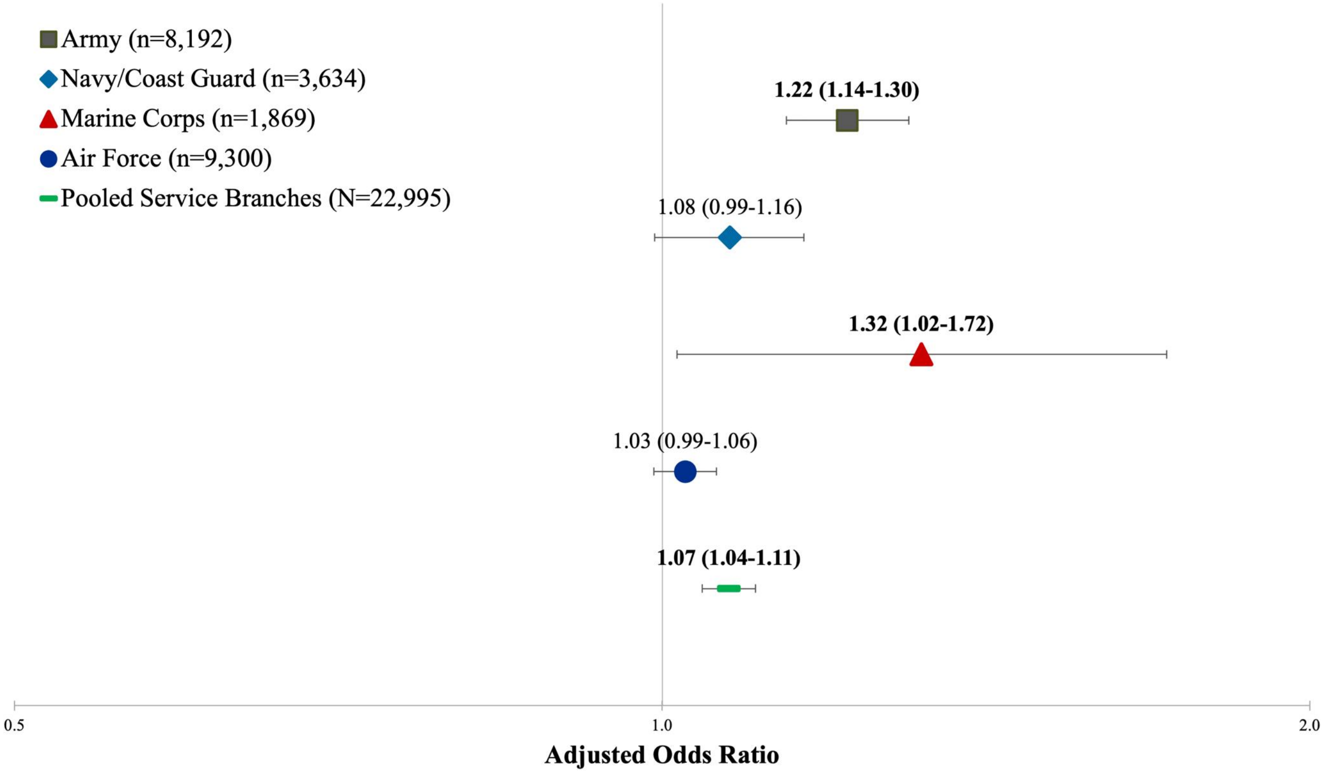

FIGURE 2 Adjusted odds ratios (95% confidence interval) of maintaining a non-obese Body Mass Index versus developing obesity with each additional deployment between baseline and follow-up. Adjusted for all covariates, the number of deployments before baseline, and time between baseline and follow-up surveys. Bolded values are statistically significant ($p < 0.05$)

research is needed to determine whether there is a threshold at which the frequency of deployment becomes detrimental to the maintenance of a healthy weight.

These analyses utilized data from a large, representative cohort of service members that conferred a high level of statistical power and generalizability. The prospective ascertainment of BMI allowed for the distinction of pre- and post-deployment body size, though measurement of BMI is limited by the reliance on self-reported height and weight, which may be less accurate than objective measures. Self-reported height and weight data in the present study could not be validated due to a lack of access to objectively collected anthropometric data from the services, though processes to obtain these data are underway for future studies. Additionally, BMI is a crude measure of body fat that does not account for variations in body types (i.e., muscular or athletic builds) and thus, it is possible that the overall body size or observed weight gain among participants may be due to increased muscle mass gained as a function of fitness maintenance and duties performed while in the field, rather than as a result of adipose tissue. While it is possible that other factors such as eating patterns, metabolism, and/or the microbiome may be altered by multiple deployments and thus, impact the observed findings, data relevant to these factors were not available for the study population and as such, their respective influences on weight maintenance could not be assessed. Due to loss to follow-up of survey non-respondents and a limited pool of participants with survey data available within a short time period after deployment, there were small sample sizes for some sub-populations (e.g., Marines with obesity), limiting statistical power in some analyses. Further, how personnel lost to follow-up may have differed from those included in the study population in their post-deployment BMI cannot be determined.

5 | CONCLUSION

These findings suggest that while multiple deployments may contribute to the maintenance of a healthy body weight, longer deployments may negatively impact post-deployment body size. Readiness involves ensuring that service members are deployable and can maintain their mission during combat or other stressful situations, and service members who are able to maintain a healthy weight may have higher levels of readiness and deployability compared with service members with obesity. Continued research in this area is necessary to determine additional modifiable behavioral factors that may be related to weight gain post-deployment and inform the optimization of service member readiness and deployability.

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CONFLICT OF INTERESTS

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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