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14. ABSTRACT

Background: Proper nutrition is essential to support warfighter performance, resilience, and health. For US Navy sailors, being deployed on ship presents challenges in maintaining healthy lifestyle behaviors. Shipboard personnel have limited food options due to storage space, and underway replenishment constraints further limit fresh and healthier food options. Despite these challenges, the consequences of this environment on health and operational readiness are not well known. The purpose of this pilot was to document afloat operational nutrition capabilities and gaps, as well as the benefits of a Registered Dietitian Nutritionist (RDN) engaging afloat sailors. Methods: Seventy-eight sailors (31 females, 47 males, age = 22–47 years) were assessed pre-deployment for dietary intake, body composition, lifestyle behaviors, and blood pressure. In addition, cardiometabolic biochemistry markers were obtained on 64 sailors. A uniformed RDN was embarked for three months to provide participants with nutrition education and counseling. Differences (mean±SE or frequencies/percentages) were assessed via ANOVAs or t-tests. Results: At baseline, 76% (47/62) of the sailors assessed had insufficient/deficient Vitamin D (25(OH)D) levels (<30ng/ml) and 43% fell outside of Navy standards for body fat percentage (BF%). In addition, 31% had blood pressures consistent with Stage 1 hypertension (i.e., systolic between 130 to 139 and/or diastolic between 80 to 89 mmHg) and 26% with Stage 2 hypertension (i.e., systolic ≥140 and/or diastolic ≥90 mmHg). Total cholesterol levels were elevated (>200 mg/dL) in 19% of participants, and HDL was below normal (<40 mg/dL) in 22% of participants. Baseline dietary intake was assessed in 69 out of 78 participants and was in line with U.S. Dietary Guidelines and Acceptable Macronutrient Distribution Range (AMDR). Healthy Eating Index-2015 scores at baseline (max pts=100) were 70 ± 1.8 for females and 62 ± 1.1 for males. The RDN provided 10 nutrition classes to 240 sailors (across all classes) and increased access to/awareness of healthy food by helping incorporate menu improvements. Overall, compliance to nutrition counseling was high (84% attending ≥1 session, 58% ≥3 sessions). Body weight (pre=82.4.0±3.6kg; post=81.1±3.5kg, p<0.001) and BF% (pre=27.0±1.5; post=22.0±1.3; p<0.001) decreased in a subset of sailors (n=27), who actively engaged in the nutrition counseling/education (i.e., attended ≥1 class and ≥2 consults). At the end of the pilot, only 13% of the participants who attended nutrition counseling remained outside of BF% standards. Body composition improved in sailors who actively participated in RDN-led nutrition education/counseling. Pre-deployment screening of 25(OH)D resulted in treatment for those who were classified as low (prescription 25(OH)D) and increased awareness in study participants. Conclusion: The findings from this pilot study suggest that RDNs could be better leveraged to help enhance afloat sailors' dietary and physical health awareness, improve nutrition related behaviors, and potentially mitigate health issues associated with the shipboard environment. More research is required to validate these findings in a wider afloat population and across other ship-classes, as well as explore the efficacy of other health promotion methodologies.

15. SUBJECT TERMS

Shipboard Diet, Dietitian, Nutrition-related Behaviors, Vitamin D

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Benefits of Deploying a Dietitian on Ship on Health Outcomes and Operational Readiness

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The study protocol was approved by the Naval Health Research Center's 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.2021.0017.

EXECUTIVE SUMMARY

Background: Proper nutrition is essential to support warfighter performance, resilience, and health. For US Navy sailors, being deployed on ship presents challenges in maintaining healthy lifestyle behaviors. Shipboard personnel have limited food options due to storage space, and underway replenishment constraints further limit fresh and healthier food options. Despite these challenges, the consequences of this environment on health and operational readiness are not well known. The purpose of this pilot was to document afloat operational nutrition capabilities and gaps, as well as the benefits of a Registered Dietitian Nutritionist (RDN) engaging afloat sailors. **Methods:** Seventy-eight sailors (31 females, 47 males, age = 22–47 years) were assessed pre-deployment for dietary intake, body composition, lifestyle behaviors, and blood pressure. In addition, cardiometabolic biochemistry markers were obtained on 64 sailors. A uniformed RDN was embarked for three months to provide participants with nutrition education and counseling. Differences (mean±SE or frequencies/percentages) were assessed via ANOVAs or t-tests. **Results:** At baseline, 76% (47/62) of the sailors assessed had insufficient/deficient Vitamin D (25(OH)D) levels (<30ng/ml) and 43% fell outside of Navy standards for body fat percentage (BF%). In addition, 31% had blood pressures consistent with Stage 1 hypertension (i.e., systolic between 130 to 139 and/or diastolic between 80 to 89 mmHg) and 26% with Stage 2 hypertension (i.e., systolic ≥140 and/or diastolic ≥90 mmHg). Total cholesterol levels were elevated (>200 mg/dL) in 19% of participants, and HDL was below normal (<40 mg/dL) in 22% of participants. Baseline dietary intake was assessed in 69 out of 78 participants and was in line with U.S. Dietary Guidelines and Acceptable Macronutrient Distribution Range (AMDR). Healthy Eating Index-2015 scores at baseline (max pts=100) were 70 ± 1.8 for females and 62 ± 1.1 for males. The RDN provided 10 nutrition classes to 240 sailors (across all classes) and increased access to/awareness of healthy food by helping incorporate menu improvements. Overall, compliance to nutrition counseling was high (84% attending ≥1 session, 58% ≥3 sessions). Body weight (pre=82.4.0±3.6kg; post=81.1±3.5kg, p<0.001) and BF% (pre=27.0±1.5; post=22.0±1.3; p<0.001) decreased in a subset of sailors (n=27), who actively engaged in the nutrition counseling/education (i.e., attended ≥1 class and ≥2 consults). At the end of the pilot, only 13% of the participants who attended nutrition counseling remained outside of BF% standards. Body composition improved in sailors who actively participated in RDN-led nutrition education/counseling. Pre-deployment screening of 25(OH)D resulted in treatment for those who were classified as low (prescription 25(OH)D) and increased awareness in study participants. **Conclusion:** The findings from this pilot study suggest that RDNs could be better leveraged to help enhance afloat sailors' dietary and physical health awareness, improve nutrition related behaviors, and potentially mitigate health issues associated with the shipboard environment. More research is required to validate these findings in a wider afloat population and across other ship-classes, as well as explore the efficacy of other health promotion methodologies.

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A. INTRODUCTION

Optimal nutritional status in service members is paramount to maintaining maximal force readiness. Degradations in dietary intake undermine human performance, especially mental health[1] and physical performance.[2] SMs diet assessments have generally shown poor nutrition behaviors including under consumption of fruits, vegetables, and whole grains and over consumption of fat and added sugar.[3,4] While such outcomes are associated with individual behavioral norms, they are also attributable to constraints associated with military environmental and operational realities. Although nutrition education has been linked to improved dietary choices in some military populations,[5] research focused on afloat personnel is limited. This understudied military population is faced with unique conditions while underway, which limits their ability to maintain optimal human performance. Afloat personnel have fewer food options due to limited storage space and underway replenishment constraints. Despite this, the consequences that this challenging environment presents on health and force readiness outcomes are not fully understood from an empirical perspective and warrant further study. To that end, this study seeks to explore the value of having a Registered Dietitian Nutritionist (RDN) embark onboard a warship to help afloat sailors optimize dietary intake for weight loss, disease prevention, and physical and mental performance. The purpose of this pilot research was to document operational nutrition capability gaps and the benefits of a RDN in an afloat setting.

RDNs are subject matter experts (SMEs) in nutritional strategies for disease prevention and human performance. The Culture of Excellence (CoE) identifies nutrition as a primary prevention tool, but currently RDNs serve in clinical settings (i.e., disease treatment). The Navy has the highest prevalence of obesity (26.7%) compared to other service branches (Air Force=15.2%, Amy=17.5%, and Marine Corps=8.4%);[6,7] obesity is costly and increases the risk for development of chronic diseases, musculoskeletal injuries, and lost workdays. Poor nutrition behaviors contribute to the development of obesity. Furthermore, all SMs, independent of weight status, would benefit from improving both the quality and quantity of dietary intake to match their needs. Specifically, proper nutrition can help to improve body composition, prevent injuries and illnesses, reduce inflammation and oxidative stress, delay muscle fatigue, accelerate recovery from physical activity, and improve cognitive function and overall force readiness.

B. METHODS

B.1. Overview

A uniformed RDN was embarked on the USS ESSEX (LHD-2), which is US Naval Surface Force Wasp-class Landing Helicopter Dock, to deliver nutrition education and counseling and assess the nutrition environment between August and November of 2021. This pilot study consisted of pre/post-deployment assessments, on ship nutrition education and counseling, and nutrition environment evaluation (Figure 1). Pre-deployment/baseline assessments took place prior to the ship getting underway and during the first month of deployment. Follow-up measurements were assessed approximately four months post-deployment. All participants were provided informed consent and this study was approved by the Naval Health Research Center (NHRC) Institutional Review Board (IRB; NHRC.2021.0017).

B.2. Pre-Deployment: Baseline Measurements

U.S. Navy sailors (31 females, 47 males, age range = 22–47 years) were assessed pre-deployment for height (m), weight (kg), body mass index (BMI, kg/m^2), body fat (BF%; assessed via Navy Body Composition Assessment standards [i.e., circumferences/taping[8]], and bioelectrical impedance [BIA; Tanita Body Composition Analyzer, BF-350, Tanita Corporation

of Americas, Inc., Arlington Heights, Illinois]), blood pressure (BP), and nutritional biomarkers (e.g., vitamin D status, lipid panel, HemoglobinA1C [HgA1c], ferritin [FE], C-reactive protein [CRP], Comprehensive Metabolic Panel [CMP], Complete Blood Count [CBC]) collected via non-fasted venipuncture. Lifestyle and occupational habits were evaluated using validated questionnaires including: the Pittsburg Sleep Quality Index (PSQI), International Physical Activity Questionnaire (IPAQ), and other Health Behaviors Questionnaires (mood state and behavioral components for diet, exercise, and subjective physical and mental health).[9]

Dietary intake was evaluated using the Diet History Questionnaire (DHQ III),[10] a validated food-frequency questionnaire which assesses food intake over the past month from a comprehensive list of 135 food and beverages and 26 dietary supplements.[10] The Healthy Eating Index (HEI-2015) was calculated from the DHQ III.

For overall health sailors were asked: "In general, how would you rate your overall health?" (Response format: 1=Poor, 2=Fair, 3=Good, 4=Very Good, 5=Excellent). For physical and mental health participants were asked "How many days during the past 30 days was your physical/mental health not good?." Health behavior questionnaires included Health Specific Self-Efficacy Scales for both nutrition and physical activity and other health related behaviors (e.g., nicotine and caffeine use). For self-efficacy scales, participants were asked five behavior questions for each prompt: "I can manage to stick to healthful foods, … even if I need a long time to develop the necessary routines, even if I have to try several times until it works, even if I have to rethink my entire way of nutrition, even if I do not receive a great deal of support from others when making my first attempts, even if I have to make a detailed plan…", "I can manage to carry out my exercise intentions, … even when I have worries and problems, even if I feel depressed, even when I feel tense, even when I am tired, even when I am busy" (response format: 1=very uncertain, 2=rather uncertain, 3=rather certain, 4=very certain, scale= 5-20).[9]

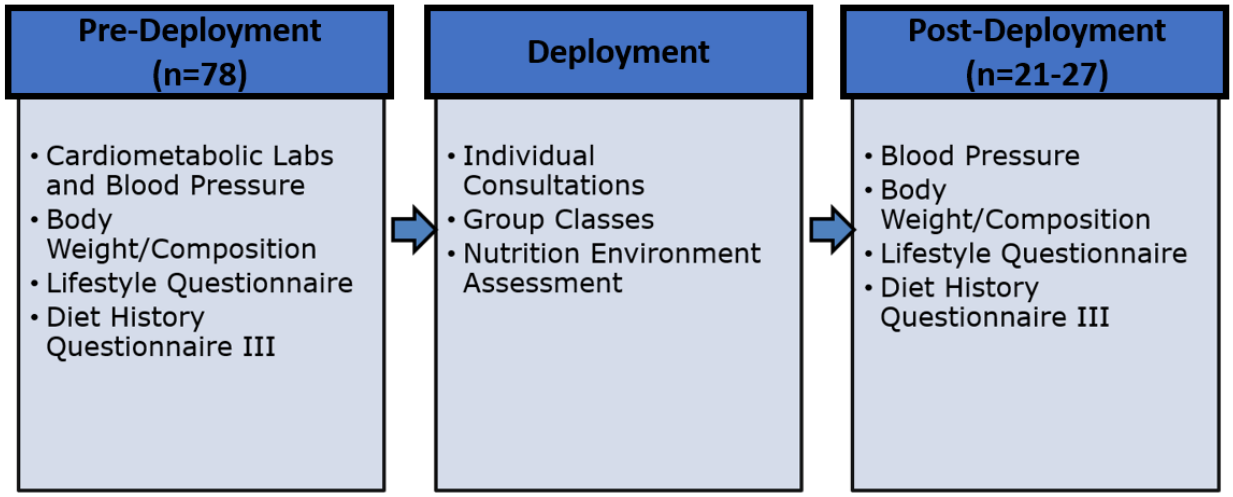

Figure 1. Study Design.

B.3. Deployment: Dietitian Assessments, Counseling, and Education

The onboard RDN completed a comprehensive assessment of the meals provided to sailors, as well as presented 10 nutrition lectures throughout deployment. Individualized counseling sessions were available and encouraged for all participants.

B.3.1. Nutrition Environment Assessment

The RDN assessed the shipboard nutrition and eating environment by evaluating the use of the Go for Green® (G4G) labeling system and by using the Military Environment Nutrition Assessment Tool (m-NEAT). G4G is an evidence-based nutrition program for military dining facilities (DFAC) to improve the food environment where service members live and work[11]. Traffic light color-coding system is used in G4G to categorize food quality, shifting attention toward nutritious items and away from less healthy items (Figure 2).

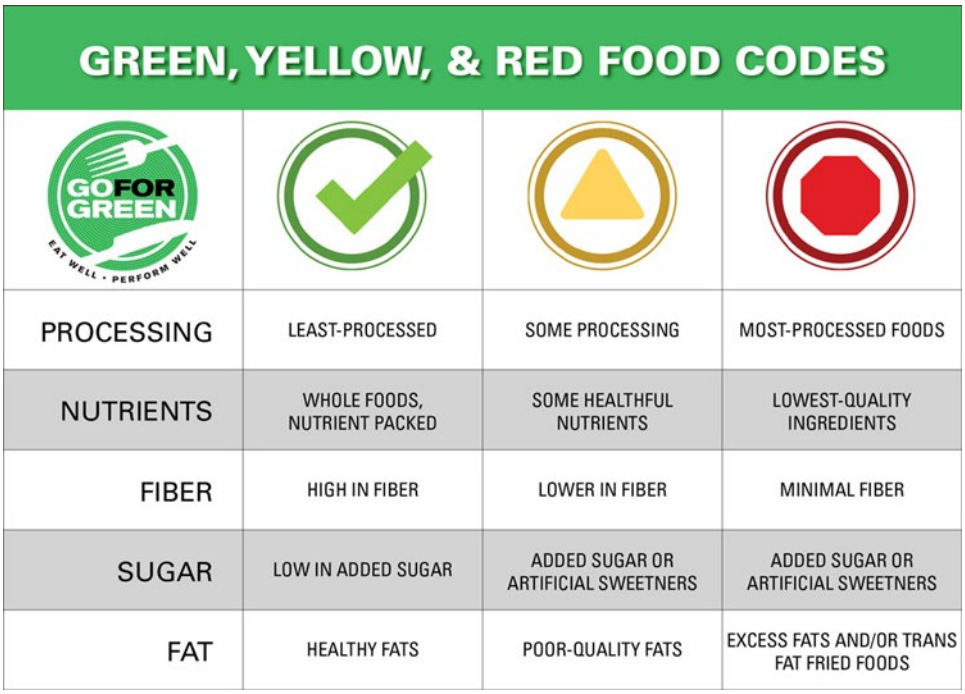

Figure 2. Go-for-Green® Infographic.
Graphic Source Uniformed Services University of the Health Sciences from
G4G Color Table | HPRC (hprc-online.org)

The m-NEAT was developed to help military communities assess their local environment and determine how well it supports/promotes healthy eating as well as what modifications could be made for improvement. Criteria assessed included: Installation Community Programs, Dining Facility (Permanent Party), Dining Facility (Training Commands), Fitness Center, Restaurant (Fast Food), Restaurant (Sit-down), Snack Shop, Stores (Convenience/Shoppette), Commissary, Vending (Refrigerated/Non-refrigerated), and Worksite.

B.3.2. Nutrition Counseling/Education

The RDN delivered nutrition education classes and provided individual counseling sessions. Nutrition education classes were delivered twice per week and topics included: Nutrition Basics, Fluid and Hydration, Supplement Safety, Heart Health, Energy Balance, Food and Mood, Carbs as Energy, Supplement Safety II, The Role of Protein, and G4G.

B.4. Post-Deployment Measurements

The post-deployment assessment was limited to a smaller sample (n=21-27) and excluded blood analysis due to abrupt changes in the study end date. Post-deployment measurements included height, weight, BMI, BF% and BP. Lifestyle, occupational, and diet habits were evaluated using the same validated questionnaires from the pre-deployment phase of the study (i.e., PSQI, IPAQ, Health Behavior Questionnaires, DHQ III).

B.5. Statistical Analysis

All data was summarized using means and standard errors or counts and frequencies as appropriate. The 25th, 50th, and 75th percentile were also presented for relevant variables. Repeated measures analysis of variance (ANOVA) was used to test for changes in BP resulting from nutritional counseling. A paired t-test was used to evaluate changes in BF% and body weight from pre- to post-deployment. The Diet History Questionnaire III (DHQ III) was used for dietary analysis and calculation of Healthy Eating Index-2015 (HEI-2015) score for diet quality[12]. Differences were assessed via ANOVA or *t* tests. Alpha was set at $p < .05$.

C. RESULTS

C.1. Pre-Deployment Assessments

Baseline assessments were completed on 78 sailors (47 male, 31 female) prior to deployment. However, due to incomplete measurements, only 72 sailors (43 male, 29 female) were included in pre-deployment body composition, BP, and metabolic biomarker calculations.

C.1.1. Subjective Pre-Deployment Measures

On average, sailors self-reported overall health as good (average score = 3.1±0.1), with 15/78 (19%) reporting overall health as poor or fair (<3). Twelve out of seventy-eight (15%) and 32/78 (41%) of sailors reported ≥ 5 days of not good physical and mental health, respectively. Self-reported participation (n=34) in vigorous and moderate physical activity was 953.8±202.3 and 2834.1±428.2 MET-min/week, respectively (Figure 3), with a mean of 396 minutes of sitting per day. More than half of sailors (54%) had poor sleep quality (average score=7±0.8; PSQI score >5=poor sleep).

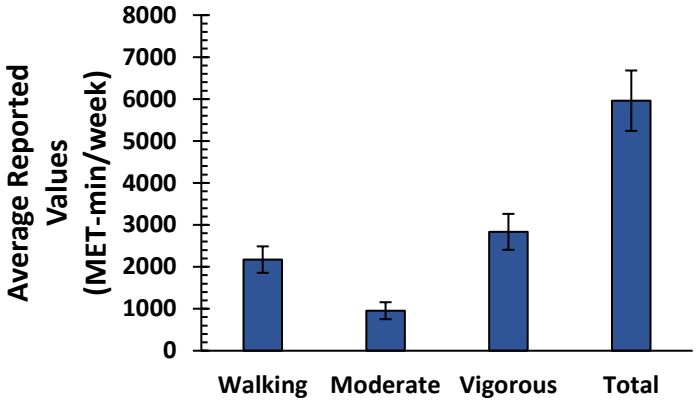

Figure 3. Pre-Deployment Self-Reported Physical Activity. Results show an average of 3 days/2843 MET-min vigorous activity per week, and 3.3 days/953 MET-min moderate activity per week.

Overall scores for nutrition and exercise self-efficacy were high (Figure 4). Participants were more confident in overcoming barriers associated with consuming healthful foods compared to fulfilling their exercise intentions; 21/78 (27%) and 44/78 (44%) had an average score of <3 (rather uncertain or very uncertain) for nutrition and exercise self-efficacy, respectively. At baseline, 69% of participants consumed caffeine (e.g., energy drinks, coffee) and 10% used tobacco/nicotine ≥1 time per day.

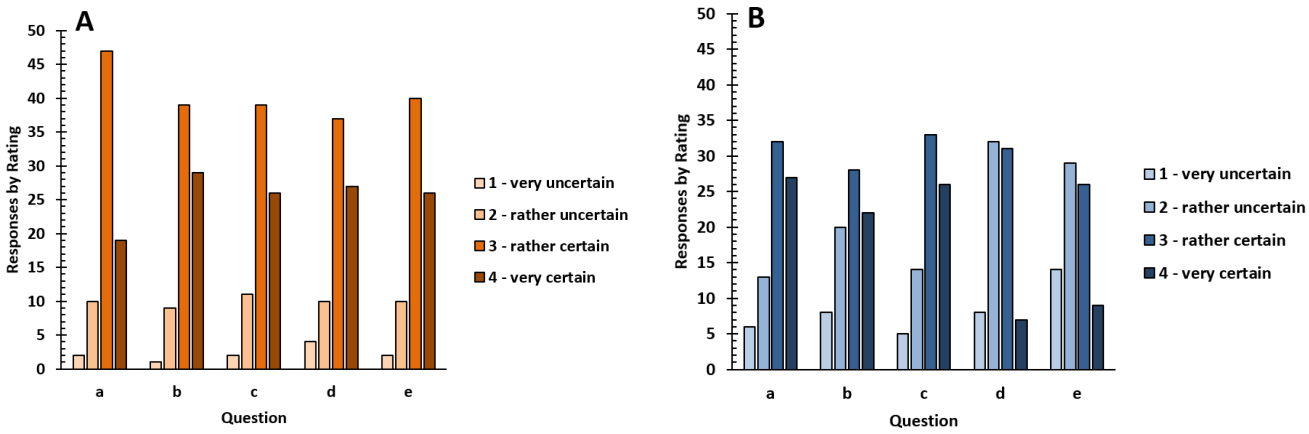

Figure 4. Pre-Deployment Health-Specific Self-efficacy Scales. Nutrition (A): I can manage to stick to healthful foods even if… a. I need a long time to develop the necessary routine; b. I have to try several times until it works; c. I have to rethink my entire way of nutrition; d. I do not receive a great deal of support from others when making first attempt; e. I have to make a detailed plan. **Exercise (B):** I can manage to carry out my exercise intentions even… a. When I have worries or problems; b. If I feel depressed; c. If I feel tense; d. When I am tired; e. When I am busy Score range = 5-20. The results of this questionnaire show that overall, the participants (n=78) are more confident at overcoming barriers associated with consuming healthful foods compared to fulfilling their exercise intentions.

C.1.2. Pre-Deployment Body Composition, Blood Pressure, and Nutritional Biomarkers

Forty percent (n=12) of females and 33% (n=15) of males were outside of Navy body composition standards[10] (females: BW=71.5±15kg, BMI=27.2±5.1kg/m^2, BF%=32.8±6.5; males: BW=93.7±2.3kg, BMI=30.8±0.6kg/m^2, BF%=23.1±0.8). Blood pressure was measured as elevated in 53% (n=42) of sailors (i.e., systolic>130 or diastolic>80mmHg) with an overall average systolic blood pressure of 129±1.9 and diastolic blood pressure 78±1.4 mmHg.

Total cholesterol levels were borderline high (170-199mg/dL; n=26) in 41% and high (>200mg/dL; n=12) in 19% of sailors. Most (75%) had normal triglyceride levels (<150mg/dL; n=52); six had levels >200mg/dL. HDL was below normal (<40 mg/dL) in 22% of sailors. HgA1C was measured as normal (5.1±0.1%), although one sailor was in the prediabetic range (HgA1C 5.7-6.4%) and one sailor was in the diabetic range (HgA1C>6.5%). Inflammation was detected in five sailors (CRP>1mg/dL), and two had elevated ferritin levels (>300mg/dL). Twelve males had high FE levels with normal CRP, indicative of iron overload (range=297 to 752mg/dl) and 13% of females had low ferritin levels <20mg/dL). One sailor had a low neutrophil count (<1500 cells/mcL), one sailor had a low lymphocyte count (<1500 cells/mcL), and one sailor had a high eosinophil count (>500 cells/mcL). Seventy-six percent (n=47) of sailors had vitamin D insufficiency or deficiency (serum 25(OH)D <30ng/ml; Figure 5).

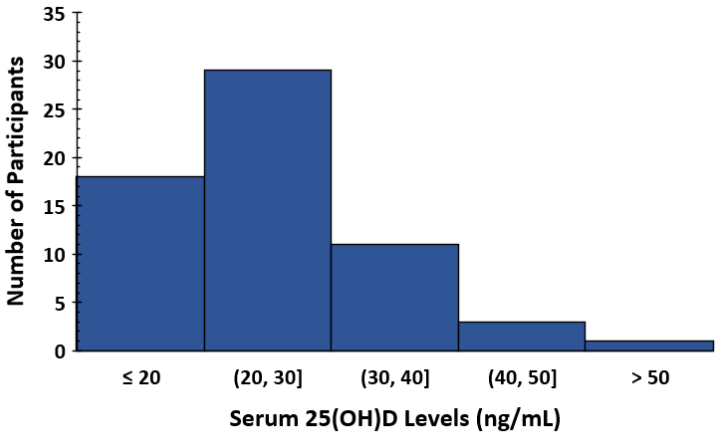

Figure 5. Pre-Deployment Distribution of Vitamin D (Serum 25(OH)D): Most sailors (76%) had insufficient (20 to <30ng/ml; n=29) to deficient (<20ng/ml; n=18) serum 25(OH)D) levels.

C.1.3. Pre-Deployment Dietary Intake and Supplement Use

Based on HEI scores (out of 100), females had higher baseline diet quality scores compared to males ($p<0.05$; Table 1), and sailors had lower scores for refined grains compared to the average adult population (19-59y; Table 1). Among sailors that reported dietary supplement intake, protein supplement use was most prevalent (meal replacement/high-protein beverage [19%], high protein/breakfast bar [44%], protein powder [33%]) and consumption of energy (20%) and sports drinks (30%). Other supplement use reported by >10 participants included: multivitamin/minerals, melatonin, omega-3/fish oil, and vitamin C (Figure 6).

Table 1. Health Eating Index-2015 (HEI-2015) Pre-Deployment

	Female (n=27)		Male (n=43)		Adults (19-59y)	
	Mean	SE	Mean	SE	Max Pts	Mean
Total HEI*	70	1.8	62	1.1	100	57
Adequacy						
Total Fruits	3.9	0.3	3.5	0.2	5	2.4
Whole Fruits	4.5	0.2	4.2	0.2	5	3.6
Total Vegetables	4.5	0.1	4.2	0.1	5	3.4
Greens and Beans	4.6	0.2	4.3	0.2	5	3.4
Whole Grains*	2.8	0.4	1.7	0.2	10	2.3
Dairy	5.2	0.4	4.8	0.1	10	5.2
Total Protein Foods	5.0	0.0	4.8	0.3	5	5.0
Seafood and Plant Protein	4.6	0.2	4.2	0.2	5	5.0
Fatty Acids*	6.8	0.5	5.5	0.4	19	4.4
Moderation						
Refined Grains†	4.4	0.5	2.6	0.3	10	6.2
Sodium*	7.6	0.5	7.9	0.3	10	3.9
Added Sugars*	8.7	0.3	7.8	0.4	10	6.7
Saturated Fats	7.1	0.4	6.9	0.4	10	5.2

HEI-2015 was calculated based on response to Diet History Questionnaire III (DHQ III). Total HEI score is out of a maximum of 100 points. Data for "Adults (19-59y)" are from the National Center for Health Statistics, What We Eat in America/National Health and Nutrition Examination Survey, 2017-

2018.[13] *Females had higher diet quality scores on these components vs. males ($p<0.05$). †Sailors had lower scores on refined grains vs. Adults (19-59y).

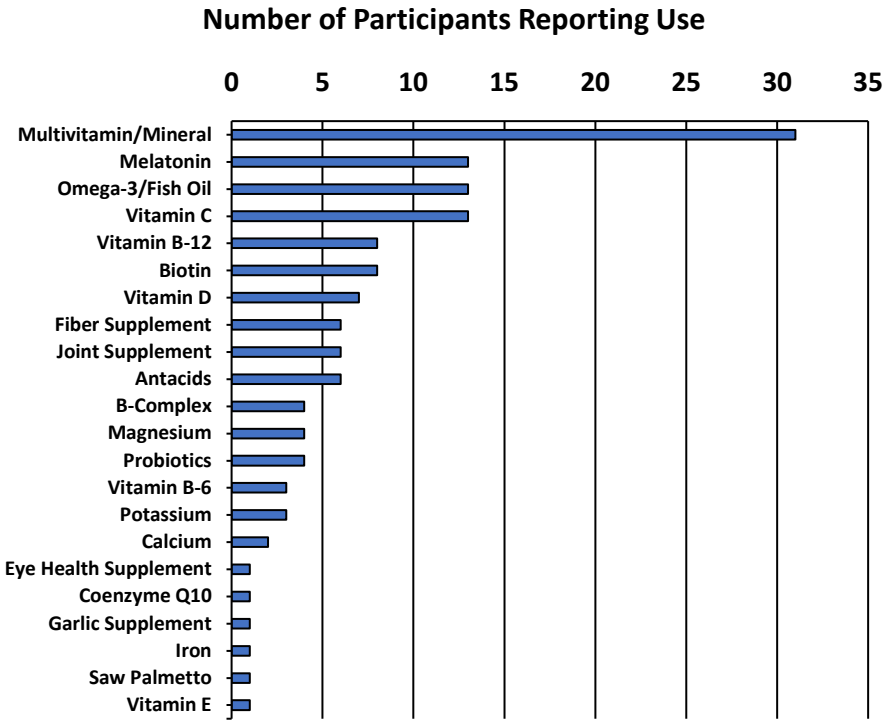

Figure 6. Pre-Deployment Supplement Use: Breakdown of pre-deployment supplement use, ranked in order from most to least prevalent.

C.2. Deployment Assessments

C.2.1. Nutrition Counseling and Education

The majority of participants were interested in improving their body composition via weight loss (79%) and/or increasing their muscle mass (17%). Overall, across the ten offered nutrition classes, 240 sailors (including non-pilot participants) attended at least one (Figure 7), and compliance to nutrition counseling was high (84% attending ≥1 session, 58% ≥3 sessions).

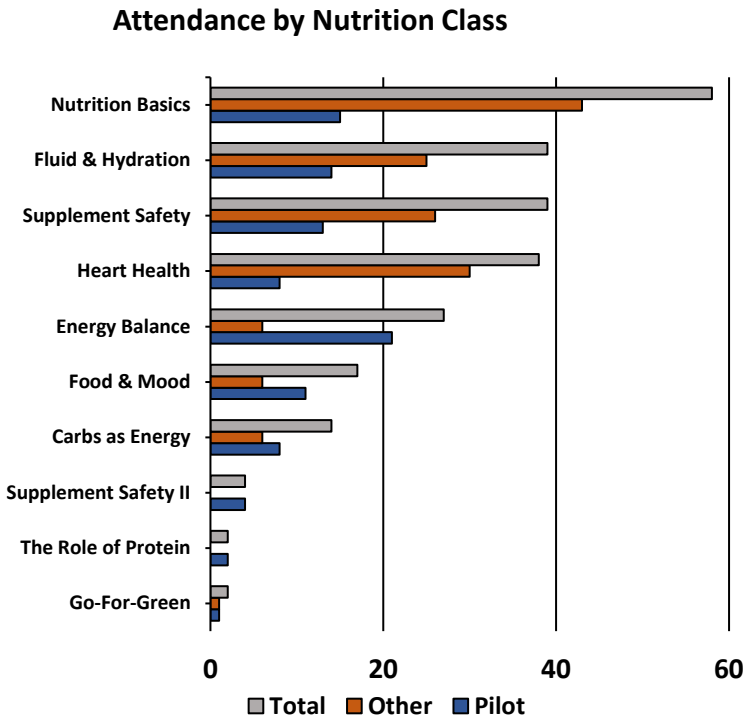

Figure 7. Nutrition Education Classes Attendance. Shipboard Personnel (Total n=240) attended nutrition education classes offered by the RDN with Nutrition Basics the most well-attended course. Total = Total Attendance; Other = Shipboard Personnel who were not enrolled in the pilot; Pilot = Shipboard Personnel who were enrolled in the Pilot.

C.2.2. Food Environment Assessment

The food environment based on m-NEAT criteria was scored as "not supportive" for healthy eating with the Mess Deck, Chief's Mess, and Wardroom scoring 41, 44, and 50% (out of 100%), respectively (Figure 8). Cycle menus were also evaluated based on G4G criteria (Figure 9), and there were few nutrient dense foods provided in the Ship's Store (Figure 10).

	Description	Mess Deck	Chef's Mess	Wardroom
Total Score	DFAC Points for each facility	14	15	17
	Maximum Possible Points	34	34	34
	Individual DFAC Score	41%	44%	50%
	Overall Score (all facilities	**45%**		

Figure 8. M-NEAT Scoring of Military Dining Facility: All areas scored using m-NEAT resulted in a classification of "Not Supported" (score of 0-59).

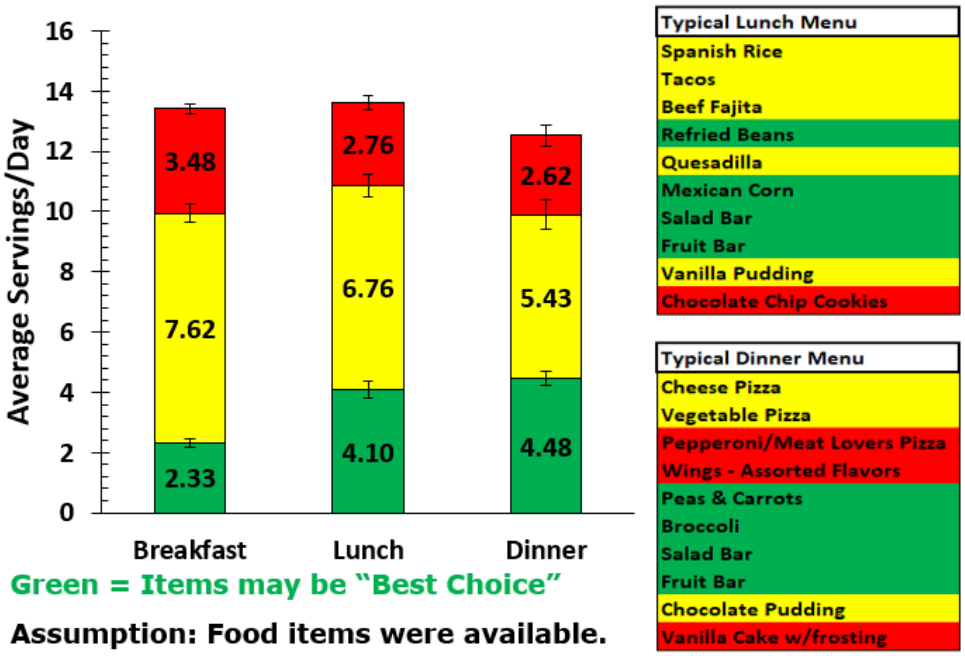

Figure 9. Go-for-Green® Scoring of Ship Cycle Menus.
Scoring of Ship cycle menu options based on Go for Green criteria including level of processing, nutrient density, fiber, sugar, and fat content.

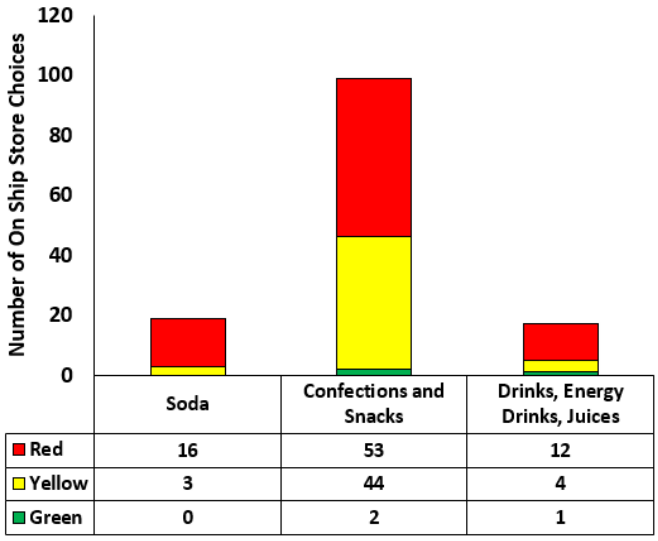

Figure 10. Go-for-Green® Scoring of Ship's Store. Most items (81 out of 135) available were labeled "red" indicative of a low nutrient quality item. RDN made suggestions on offerings to improve ship's store food environment.

C.3. Post-Deployment Assessments

C.3.1. Subjective Post-Deployment Measures

Post-deployment subjective, self-reported measures were the same as those evaluated pre-deployment, although the sample was smaller (n=21-27) due to the abrupt change in pilot end date. Post-deployment, participants self-reported overall health as good (average score = 3.4±0.2); 3/27 (11%) self-reported overall health as poor or fair (<3). Three out of twenty-seven (11%) and 7/27 (26%) of sailors self-reported ≥ 5 days of not good physical and mental health, respectively. Self-reported participation (n=21) in vigorous and moderate physical activity was 854.4±274.3 and 1489.1±443.4 MET-min/week ($p>0.05$ pre- vs. post-deployment), respectively, and sleep quality significantly improved (n=24; average score=3.7±0.5, $p=0.0006$).

Scores for nutrition and exercise self-efficacy were similar to baseline (overall average for: nutrition=16.0±0.1; exercise=13.6±0.2) with 8/27 (29%) for nutrition self-efficacy and 13/27 (48%) for exercise self-efficacy having an average score for each question of <3 (rather uncertain or very uncertain). Post-deployment (n=27) caffeine consumption and tobacco/nicotine were similar to baseline as well.

C.3.2. Post-Deployment Body Composition and Blood Pressure

A mean reduction of 1.28±.03 kg in body weight was found from pre- to post-deployment assessment (n=27, pre=82.4.0±3.6kg, post=81.1±3.5kg, $p<0.001$). Body composition improved from pre- compared to post-deployment (pre=27.0% BF ± 1.5 vs. post=22.0 % BF ± 1.3; $p<0.001$) resulting in only 13% of sailors remaining outside of Navy standards. No differences were found between BP pre- to post-deployment.

C.3.3. Post-Deployment Dietary Intake and Impact

Energy, %carbohydrate, and fat intakes were significantly lower ($p<0.05$) for females (n=9), and as expected alcohol intake was significantly lower for females (n=9) and males (n=16) post-deployment (Table 2). Based on documented nutrition counseling case studies, the mean weight loss in 38 sailors was 6%, with an 18% decrease in BF%, and BP was lower in eight participants with initially elevated levels.

Table 2. Energy, Macronutrient, and Alcohol Intake

	Female (n=9)			Male (n=16)		
	Pre Mean (SE)	**Post** Mean (SE)	**Pre vs. Post** (p-value)	**Pre** Mean (SE)	**Post** Mean (SE)	**Pre vs. Post** (p-value)
Energy (kcal)*	2582.6 (388.2)	1763.1 (294.7)	**0.029**	2154.0 (256.2)	1734.3 (152.3)	0.142
Carbohydrate*						
g/day	290.4 (50.3)	219.9 (32.7)	0.078	237.4 (23.3)	214.8 (18.5)	0.329
% Total Kcal	44.3 (2.1)	50.9 (1.1)	**0.027**	45.4 (1.6)	49.5 (1.5)	0.935
Protein						
g/day	114.6 (17.2)	86.6 (17.8)	0.233	97.7 (14.7)	84.3 (8.2)	0.424
% Total Kcal	17.8 (0.9)	19.5 (1.2)	0.374	17.9 (0.7)	19.5 (0.8)	0.141
Fat*						
g/day	101.5 (15.0)	62.0 (11.2)	**0.014**	81.2 (10.7)	62.0 (6.2)	0.144
% Total Kcal	35.7 (1.7)	31.0 (1.4)	**0.027**	33.5 (1.0)	32.1 (1.0)	0.433
Alcohol*[a]						
Number of Drinks	1.0 (0.3)	0.1 (0.0)	**0.010**	1.2 (0.3)	0.2 (0.1)	**0.007**
% Total Kcal	2.3 (0.5)	0.4 (0.1)	**0.003**	2.7 (0.6)	0.5 (0.2)	**0.001**

*Females had lower energy, %carbohydrate, fat, and alcohol intake. [a]Males had lower alcohol intake ($p<0.05$).

D. CONCLUSION

This is the first known study assessing the effectiveness of an embarked uniformed RDN. The findings, albeit limited, suggest that RDNs could be better leveraged to help enhance afloat SM's dietary and physical health awareness, improve nutrition related behaviors, and potentially mitigate health issues associated with the shipboard environment. This pilot study provided evidence that the embarkation of a RDN onboard the USS ESSEX helped improve nutrition related behaviors and health status of the sailors under study as well as awareness of the shipboard nutrition environment. Key baseline health findings included 76% of participants having insufficient/deficient serum 25(OH)D levels, 35% (n=28) of sailors being outside of Navy BCA standards, and 53% (n=42) having elevated BP (>130/80 mmHg). Through nutrition education and counseling the RDN helped facilitate improvements in self-reported general and mental health and sleep, body weight/composition, and BP. Evaluations of the nutrition environment also increased access to healthier food options by helping to incorporate menu improvements and facilitating improved awareness of higher quality foods using the G4G labeling system. Participants overall had baseline dietary intakes that were in line with U.S. Dietary Guidelines energy and macronutrient recommendations [14] and, excluding whole grains, dietary quality scores (HEI-2015) were similar to the general U.S. population. The RDN was able to facilitate dietary improvements with decreases in fat and increases in whole grain intake for female and male sailors, respectively.

The study had several limitations which future research should address: 1) the sample size was limited in relation to the overall US Navy afloat population; 2) the underway replenishment of fresh foods was problematic; the ship under study went ~5 weeks with no port calls or underway replenishments, limiting the availability of healthier/higher quality food recommendations; 3) the busy and dynamic work schedules of shipboard sailors limited their availability for nutrition education and consults; 4) COVID-19 pandemic protocols at the time resulted in the ship's fitness space being closed thus limiting exercise options (although the RDN was able to help facilitate weight maintenance/loss via diet); and 5) this pilot study only focused on one ship-class and therefore did not account for the unique environmental and operational requirements.

This is the first study assessing the effectiveness of a deployed Navy RDN within the ship environment. Findings show that realigning RDNs to the fleet may help lead to increased dietary and physical health awareness, improved nutrition related behaviors, and potentially mitigate health issues associated with the afloat environment. Future research should be conducted with a larger sample size and include a control group.

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