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Effect of Military Deployment on Diabetes Mellitus in Air Force Personnel

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ABSTRACT Introduction: Military deployments relocate service members to austere locations with limited medical capabilities, raising uncertainties whether members with diabetes can participate safely. Military regulations require a medical clearance for service members with diabetes prior to deployment, but there is a dearth of data that can guide the provider in this decision. To alleviate the lack of evidence in this area, we analyzed the change in glycated hemoglobin (HbA1c) and body mass index (BMI) before and after a deployment among active duty U.S. Air Force personnel who deployed with diabetes. Materials and Methods: A retrospective analysis was conducted using HbA1c and BMI values obtained within 3 mo before and within 3 mo after repatriation from a deployment of at least 90 d between January 1, 2004 through December 31, 2014. The study population consisted of 103 and 195 subjects who had an available pre- and post-deployment HbA1c and BMI values, respectively. Paired *t*-tests were conducted to determine significant differences in HbA1C and BMI values. Results: The majority (73.8%) of members had a HbA1c <7.0% (53 mmol/mol) prior to deployment. For the overall population, HbA1c before and after deployment decreased from 6.7% (50 mmol/mol) to 6.5% (40 mmol/mol) ($p = 0.03$). Subgroup analysis demonstrated a significant decline in HbA1c among males, those aged 31–40 yr, and those with a pre-deployment HbA1c of >7%. BMI declined for the overall population (28.3 kg/m^2 vs. 27.7 kg/m^2, $p < 0.0001$) and for most of the subgroups. Conclusion: Air Force service members who deployed with diabetes, including those with a HbA1c > 7%, experienced a statistically significant improvement in HbA1c and BMI upon repatriation. A prospective study design in the future can better reconcile the effect of a military deployment on a more comprehensive array of diabetes parameters.

The continuing rise of diabetes in the U.S. threatens to affect even those whose occupations require physical fitness. The U.S. Armed Forces require service members to meet physical fitness and anthropometric standards, yet despite their active lifestyles, they remain vulnerable to developing diabetes. It is estimated that nearly 3% of U.S. service members have diabetes.[1] A study by Paris et al characterizing U.S. service members who develop type 2 diabetes suggests that the mean age at diagnosis is 35.2-yr old, affected after an average of 13.6 yr of military service.[2] Despite a lifetime of adherence to physical fitness standards, diabetes can still affect service members at the height of their military careers.

Having a chronic medical condition does not necessarily preclude continued military service. However, diabetes presents unique occupational challenges. Chief among them is the geographic limitation that diabetes imposes due to certain physiologic limitations, environmental challenges, and the lack of reliable medical access in certain duty locations. However, the U.S. military has been involved in areas of conflict globally over the past two decades[3] and, inevitably, some members with diabetes have been deployed to these locations despite their condition. From beginning to end, a deployment involves physical and physiologic challenges that can derail a patient's personal strategy to maintain glycemic control. The journey alone to these operational areas can involve days of overseas travel, heavy load carriage, and multiple changes in time zones, causing disruption of regular sleep, diet, and activity routines. Some operational areas can be quite austere and geographically unforgiving, marked by temperature extremes, high altitudes, and unsanitary conditions.[4] For the same reasons, medical capability in these regions may be limited to a medic or individual first-aid.

To protect its members, the U.S. Department of Defense (DoD) requires medical clearance for all members prior to deployment. Military medical providers are given the discretion to concur with a deployment if they anticipate that a chronic medical condition will not unexpectedly worsen in a deployed environment.[5] However, there is a dearth of information regarding the glycemic effects of living in challenging circumstances such as a military deployment, and thus, the DoD lacks specific guidance in this domain. Current literature

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on the military experience with diabetes has been limited to case reports and observation of those with type 1 diabetes[6–10] who are almost always restricted from deployment or continued military service. We recognized the need to further explore this area of military medicine in order to guide providers in their medical decision-making and potentially influence future medical defense policies. Therefore, we conducted a retrospective analysis to characterize U.S. Air Force members with diabetes who have deployed, to include their diabetes treatment, and to analyze the changes in their HbA1c and BMI before and after a deployment.

RESEARCH DESIGN AND METHODS

Data were collected from the Military Health System (MHS) Management Analysis and Reporting Tool, which contains health care service data provided by military treatment facilities, civilian providers, hospitals, managed care support contractors, the Defense Manpower Data Center, and the Pharmacy Data Transaction Service, including inpatient, outpatient, pharmaceutical, and enrollment data. Laboratory data came from the MHS Composite Health Care System.

The study population included active duty members of the U.S. Air Force with a diagnosis of diabetes who completed a deployment of at least 90 d between January 1, 2004 and December 31, 2014. Deployed U.S. Air Force members included all regular Air Force active duty personnel as well as members of the Air National Guard and Air Force Reserve who were activated for deployment. Diabetes was defined by the presence of a "Diabetes Mellitus" diagnosis according to the Healthcare Effectiveness Data and Information Set (HEDIS) criteria. HEDIS methodology identifies patients with diabetes by evidence of either a diabetes-related diagnosis code in claims/encounter data or a dispensed diabetes-related medication in pharmacy data within the past 24 mo. Subjects were excluded from analysis if their diagnosis was made after December 31, 2014, if they deployed for less than 90 d, if they did not have an HbA1c or BMI available within 3 mo prior to deployment and within 3 mo upon repatriation, or if the member became pregnant during deployment or within 3 mo upon repatriation.

The blood samples for HbA1c and BMI measurements were obtained at any of the U.S. military treatment facilities worldwide either for a pre- or post-deployment medical evaluation or another form of clinical encounter unrelated to deployment. The HbA1c and BMI values that were included in the analysis were those collected at the time most proximal to, but within 3 mo of, the deployment date and at the time most proximal to, but within 3 mo of, the date of repatriation.

The presence of comorbid conditions before and after deployment was identified through relevant ICD-9 diagnosis codes. Diabetes-related medication data were collected by querying for relevant American Hospital Formulary Service therapeutic classes. Counts of the number of dispenses per therapeutic class by time period (before, during, and after deployment) were calculated for each individual.

The study protocol was approved by the Air Force Regional Institutional Review Board at Wilford Hall Ambulatory Surgical Center (WHASC) and the Defense Health Agency Privacy Office prior to data collection.

Analysis was conducted using SPSS version 19. Univariate analysis allowed for a description of the population including demographic characteristics, medication, comorbidities, and clinical measures before and after deployment. In addition, paired t-tests were conducted to determine significant differences in HbA1c and BMI before and after deployment. Paired *t*-tests were conducted in stages including the overall group, those not on medication, and subgroups according to medication regimen. Additional subgroups were analyzed according to BMI and HbA1c categories.

RESULTS

We identified 366 U.S. Air Force members with a diagnosis of diabetes at the time of deployment of at least 90 d between January 1, 2004 and December 31, 2014. Paired pre- and post-deployment HbA1c and BMI were available for 103 (28.1%) and 195 (53.3%) members, respectively. These members were included in the analysis. Other members not included in the analysis were 97 (26.5%) who had paired HbA1c drawn beyond the 3-mo window of departure and repatriation, 43 (11.8%) with an unpaired HbA1c drawn prior to deployment only, 33 (9%) with an unpaired HbA1c drawn after deployment only, and 90 (24.6%) without any HbA1c values within the 3-mo window. The mean HbA1c for those who had a pre-deployment value only was 6% (42 mmol/mol).

Table I summarizes the characteristics of members with paired pre- and post-deployment HbA1c. The majority were men (88.3%) and most were in the 31–50 age group (83.5%). The majority were in the enlisted corps (74.8%), consistent with the 4-fold preponderance of enlisted personnel compared with officers in the U.S. Air Force.[11] About half had coexisting diagnoses of lipid disorders and/or hypertension. Only a minority were diagnosed with microvascular complications.

Most of the members (83.5%) were prescribed at least one diabetes medication at the time of deployment, most commonly metformin (n = 71, 82.6%), followed by sulfonylureas (n = 27, 31.4%), dipeptidyl peptidase-4 (DPP-4) inhibitors (n = 21, 24.4%), and thiazolidenediones (TZD) (n = 13, 15.1%). None were on meglinitides, alpha-glucosidase inhibitors, or sodium-glucose co-transporter-2 (SGLT-2) inhibitors. Insulin, the most common injectable medication in the group, was prescribed to 9 (10.5%) members. Glucagon-like-peptide-1 receptor agonists (GLP-1 RA) were prescribed to 3 (3.5%) members. There were no members on an amylin analog. Half (n = 43, 50%) were on monotherapy while 36% were on dual therapy, most commonly metformin plus a sulfonylurea. Metformin plus TZD and metformin plus a DPP-4 inhibitor

TABLE I. Characteristics of the Study Sample with Paired Pre- and Post-Deployment HbA1c[a] ($n = 103$)

Variable	Number (%)
Gender	
Male	91 (88.3)
Female	12 (11.7)
Age groups	
18–30	8 (7.8)
31–40	40 (38.8)
41–50	46 (44.7)
51+	9 (8.7)
Rank	
Officers[b]	26 (25.2)
Enlisted[c]	77 (74.8)
Comorbidities	
Hypertension	48 (46.6)
Lipid disorders	59 (57.3)
Retinopathy	2 (1.9)
Nephropathy	0 (0)
Neuropathy	1 (1.0)
No diabetes medication prescribed	17 (16.5)
Diabetes medication(s)prescribed	86 (83.5)
HbA1c	
<7%	76 (73.8)
7–7.9%	19 (18.4)
8–8.9%	3 (2.9)
≥9%	5 (4.9)

[a]Data reflect status prior to deployment.
[b]Officers include personnel with ranks second Lieutenant to General and Warrant Officers.
[c]Enlisted include personnel with ranks Airman Basic to Chief Master Sergeant of the Air Force.

were the second and third most common dual regimen, respectively.

Changes in HbA1c

The majority (73.8%) of members had a HbA1c <7.0% (53 mmol/mol) prior to deployment (Table I). Comparing values before and after deployment, mean HbA1c decreased from 6.7% (50 mmol/mol) to 6.5% (48 mmol/mol), which was a statistically significant change ($p = 0.03$). Those who deployed with a HbA1c >7% also experienced a significant decline in HbA1c from 7.9% (63 mmol/mol) to 7.1% (54 mmol/mil) ($p = 0.0029$), as did the males and those in the age 31–40 subgroups (Fig. 1).

Figure 2 illustrates the HbA1c responses among various medication subgroups. None of these subgroups demonstrated a statistically significant change in pre and post-deployment HbA1c values. However, it is worth noting that, in almost all of the oral medication subgroups, pre and post-deployment HbA1c values were <7%. In contrast, the insulin subgroup maintained their mean HbA1c above 7%.

Changes in BMI

At the time of deployment, the mean BMI for the overall population was in the overweight category (BMI 28.3 kg/m^2). Over the course of deployment, the mean BMI demonstrated a statistically significant decline from 28.3 kg/m^2 to 27.7 kg/m^2 ($p < 0.0001$). Most of the subgroups also experienced a significant decline in BMI except for officers and those over age 50. The decline in BMI was unrelated to the pre-deployment HbA1c (Fig. 3).

CONCLUSIONS

It is imperative that the deliberations to deploy a service member with diabetes consider all the factors that can compromise the member's safety and the ability to accomplish the mission. Herein, we provide objective data to illustrate the glycemic and BMI responses to a military deployment among U.S. Air Force members with diabetes. We anticipate that these findings would be of value not only to military medical providers and leaders, but also to the general network of providers who care for service members and are asked to comment on their deployment candidacy.

We deemed that a HbA1c of <7% is an appropriate threshold for deployment based on the American Diabetes Association's (ADA) recommended HbA1c target for most adults,[12] particularly in a relatively young and healthy population. In this study, most members were meeting this HbA1c standard prior to deployment, which improved further upon repatriation, reflecting a change that was statistically significant. Excluding any diabetes-related complications, a HbA1c that remained <7% upon repatriation would suggest that the member likely escaped troublesome glycemic excursions during course of their deployment. For a military provider who can exclude any history of severe hypo or hyperglycemic episodes during a service member's deployment, a relatively stable HbA1c upon repatriation is an encouraging finding. Our results show that, across multiple subgroups, well-managed diabetes prior to deployment remained so after deployment. Even those with HbA1c above an ideal target prior to deployment experienced a significant improvement upon return.

HbA1c and Medications

We paid particularly close attention to our population's medication regimen as certain medications with unfavorable side effect profiles or complicated administration can disqualify a member from deployment. It is logical that the most salutary pharmacologic regimen in deployment consists of oral medications due to their ease of administration and durability during travel.[13] Military providers recognize this as members in our study who required diabetes medications were usually on oral agents. The most commonly prescribed medication was metformin, consistent with the ADA, American Association of Clinical Endocrinologists (AACE), and Veterans' Affairs (VA)/DoD clinical practice recommendations.[12–15] For those who tolerate metformin, we agree that metformin has an adequate safety profile for deployment. Our data also demonstrate that those who deployed on

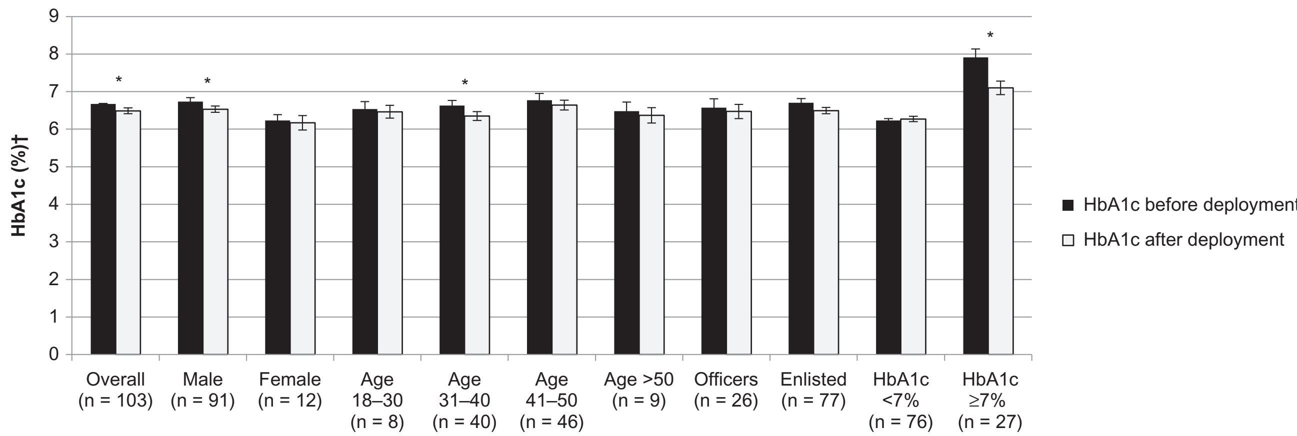

FIGURE 1. HbA1c before and after deployment for the overall population and subgroups. Data represents mean HbA1c +/− SE. *$p < 0.05$. †[10.93 × HbA1c%]–23.5 = mmol/mol.

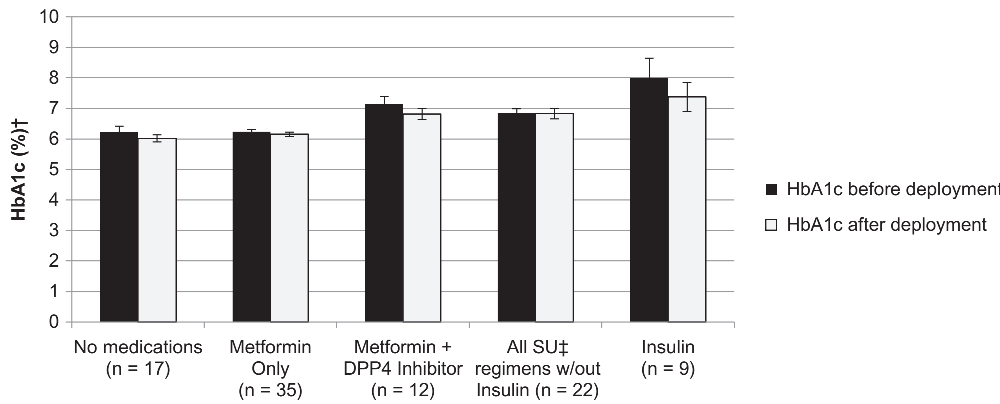

FIGURE 2. HbA1c before and after deployment based on therapeutic interventions. Data represents mean HbA1c +/− SE for those with paired HbA1c values. †[10.93 × HbA1c%]–23.5 = mmol/mol. ‡Sulfonylurea-containing.

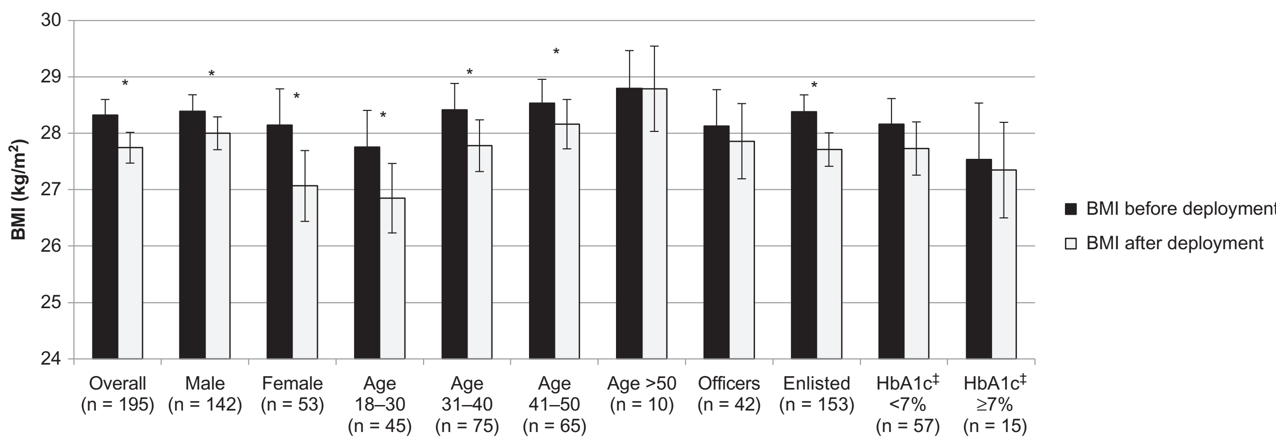

FIGURE 3. BMI before and after deployment for the overall population and subgroups. Data represents mean BMI +/− SE. *$p < 0.05$. ‡Data represents those with paired HbA1c and BMI values.

metformin monotherapy maintained their HbA1c within a good range.

The finding that members on sulfonylureas and insulin were cleared to deploy was surprising. Sulfonylureas and insulin are known to cause hypoglycemia, an unacceptable risk in deployment particularly for those who are intensively controlled.[16,17] Nevertheless, we found that sulfonylureas were the second most common oral therapy prescribed and the most common medication combined with metformin. It is unclear to what extent hypoglycemia occurred in these members as our data collection method was not designed to readily capture this information. Even so, we are not aware of any reports of hypoglycemia causing significant problems for service members with diabetes in the deployed setting.

Although it is well recognized that sulfonylureas can cause hypoglycemia, the decision to continue them may have been partly due to the lack of incentive to modify medications for those who are already meeting glycemic targets. Despite the availability of other oral agents with better safety profiles, HbA1c stability on a sulfonylurea-containing regimen may have been viewed more favorably by military providers since medication adjustments and routine diabetes clinical encounters are generally not expected in a deployed setting.[13] Additionally, choosing a sulfonylurea as a first or second-line agent was consistent with the prevailing prescribing practice within our study period. An analysis on prescription trends for diabetes medications filled in U.S. retail pharmacies from 2003 to 2014 demonstrated that the volume of sulfonylurea prescriptions remained constant despite the emergence of newer agents.[18] In this study, those on sulfonylureas maintained a stable HbA1c, but the possibility of hypoglycemic events during their deployment cannot be excluded.

Surprisingly, nine members were deployed while on insulin, a medication that is more challenging to manage in a deployed environment. Severe hypoglycemia, sustained hyperglycemia, and other catastrophic glycemic crises can occur when critical tasks acutely arise causing missed meals and ill-timed insulin doses. Additionally, appropriate storage facilities are either unreliable or simply non-existent in a combat theater. The Food and Drug Administration (FDA) recommends that insulin be refrigerated at approximately 36°F (2.2°C) to 46°F (7.8°C). It can maintain its integrity if left at room temperature (59°F [15°C] −86°F [30°C]) for up to 28 d, but exposure to extreme heat or freezing temperatures will reduce its potency.[19] Unfortunately, over the course of a deployment, a member may transition several times to different locations and climates, precluding reliable access to appropriate storage facilities or a pharmacy. In contrast to those on oral medications, those who deployed on insulin had higher HbA1c values prior to deployment, which may reflect more advanced disease, but also permissive hyperglycemia to avoid hypoglycemic episodes. Because of the challenges inherent to deployments, relaxation of glycemic targets among insulin-users may have been a practical necessity.

The latter portion of our study period saw the emergence of newer medication classes without hypoglycemic side effects, but because of timing of DoD formulary approval and other medication factors, they were not prescribed as commonly. The safety profile of DPP-4 inhibitors is favorable enough for deployment, but was likely not utilized as often due to the novelty of the drug class at the time. However, the DoD now recognizes the safety of this drug class as some Air Force aviators, a group rigorously monitored for medical complications, are retained in their aviation duties despite taking DPP-4 inhibitors.[20] GLP-1 RA may also be potentially safe in certain deployment settings if adequate storage facilities are available. FDA approval for SGLT-2 inhibitors fell at the end of our study period,[21] but this class is not likely to be utilized often due to the concern for volume depletion. TZDs may also be safe in deployment, but at the time of our study period, there were safety concerns regarding its role in heart failure and bladder cancer,[18] leaving metformin and sulfonylureas as the most popular oral options. As providers gain familiarity with newer agents, perhaps future deployers requiring diabetes medications will be placed on those with better safety profiles.

BMI and Physiologic Challenges Affecting HbA1c

The decline in BMI seen in our population coincides with the findings in existing literature on body composition changes following military deployments, particularly those that are less than 7 mo in duration. Studies on U.S. and British soldiers who deployed to Afghanistan for 4–9 mo reduced their body mass by 2–5% reflecting a decrement in both fat and lean mass.[22–24] However, other studies with longer deployment durations suggest that lost body weight tends to recover, or even exceed pre-deployment weights, potentially owing to an increase in fat mass.[25,26]

Reduction in weight has been shown to improve glycemic control[12,14,15,27] and our results coincide with the literature. Although our results demonstrate favorable and concordant findings in terms of HbA1c and BMI responses to deployment, glycemic management can be affected other physiologic challenges in a deployed setting, which may be subject to future systematic analyses.

A physiologic stressor that is ubiquitous among deployed military members that can impede glycemic management is sleep disturbance.[4] Sleep quality surveys administered to military members during and after deployment revealed that members received significantly shorter sleep durations and sustained more sleep disturbances compared to those who did not deploy.[28] Sleep deprivation and misalignment of circadian rhythms can promote insulin resistance by increasing counter-regulatory hormones and activating the sympathetic nervous system.[29] The impairment in cognition after disrupted sleep can also lead to mistakes in medication administration, leading to excessively high and low glucose excursions.

Related to sleep disturbance is the high prevalence of mental health problems resulting from deployment such as depression, post-traumatic stress disorder, and anxiety.[30,31] A meta-analysis suggested that depression was significantly associated with worse HbA1c, with an effect size that was small to moderate.[32,33] A proposed mechanism for this psychosomatic interaction involves a more sustained increase in cortisol experienced by people with depression after a psychologically stressful event compared with those without depression.[34] Likewise, anxiety and post-traumatic stress disorder have also been associated with poorer glycemic control.[35,36]

Dietary content and quality also inevitably change in deployment. The overall diet in a deployed environment, as measured by total Healthy Eating Index-2010 score, is considered sub-optimal due to limitations in the quality and availability of perishable food items.[37] The limitation in food choices, especially those with lower glycemic indices, is likely to contribute to hyperglycemia.[38]

Strengths and Limitations

This study is the first attempt to characterize the impact of military deployments on Air Force service members with diabetes. A major strength of this study is that it was able to capture data from every deployment in the time period studied, such that a comprehensive review could be accomplished, accounting for HbA1c change, weight change, and medication use. Prior to this analysis, the number of Air Force members who deployed with diabetes was unknown.

There are also several limitations of this study. As with any large data set review, none of the service members with diabetes were interviewed, and none of the specific medical records were scrutinized, so specific details about each member were lacking. We can only speculate on the reasons why only a third of the members had a HbA1c drawn within ideal intervals before and after deployment. From our own deployment experiences, various pre- and post-deployment training and activities can take precedence over medical follow-ups. Additionally, as previously mentioned, our study design did not allow us to capture the incidence of hypoglycemic events in members using insulin or sulfonylureas, which could have an adverse impact in certain deployed scenarios. Even so, we are not aware of any reports indicating this issue to be a significant problem. Perhaps, the largest limitation was the lack of information about the deployment location for each member, which was not attainable in our methodology. As a result, we were not able to make associations about the austerity of particular deployment locations with the measures of interest in this study. Of course, the majority of deployments for military personnel in our study interval occurred in Afghanistan and Iraq, and virtually all of the locations had reduced medical services compared to what would be available at their original duty stations. As our methodology prevented us from reviewing the specific environment for each member in the study, determinations about which environments led to our results cannot be made. It is also possible that service members with diabetes, although allowed to deploy, may have been restricted to less austere environments because of their condition. Even so, it is reasonable to assume that this study provides data that can be used to formulate policy regarding deployment of members to facilities with standard medical and food services found in fixed locations. This data could also be applicable in civilian settings in which a person with diabetes desires to participate in activities in an underserved part of the world.

This study provides insight into how service members with diabetes respond to deployment and can serve as a resource for military medical providers and leaders seeking guidance on the feasibility of deploying this population. Some members with diabetes, even those who require medications, appear to be adequately "fit to fight" as their HbA1c were mostly maintained within reasonable levels. However, medical practice can be improved by thoughtful consideration of a member's glycemic management and medication requirements prior to deployment, as well as encouraging timely follow-up upon return. In the future, a prospective design could overcome several of the limitations in this study and provide a more robust basis to guide clinical decisions and policy development.

PREVIOUS PRESENTATIONS

77th American Diabetes Association Conference, San Diego, CA, June 2017.

3rd Annual San Antonio Military Health System and Universities Research Forum, San Antonio, TX, June 2017.

Military Health System Research Symposium, Orlando, FL, August 2017.

CONFLICT OF INTEREST

T.J.S. serves in the speaker's bureau for Merck and AstraZeneca.

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