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Short communication

# Lung function abnormalities among service members returning from Iraq or Afghanistan with respiratory complaints☆,☆☆

Aaron B. Holley [a,*], Michal Sobieszczyk [a], Michael Perkins [a], Brian M. Cohee [a], Camille B. Costantoth [b], Donovan L. Mabe [a], Robert Liotta [c], Joseph H. Abraham [d], Paul R. Holley [e], John Sherner [a]

[a] Department of Pulmonary, Critical Care, and Sleep Medicine, WRNMMC, 8901 Rockville Pike, Bethesda, MD 20889, United States
[b] Department of Internal Medicine, WRNMMC, 8901 Rockville Pike, Bethesda, MD 20889, United States
[c] Department of Radiology, WRNMMC, United States
[d] Occupational and Environmental Medicine, USAPHC, United States
[e] Department of Informatics, US Army Medical Research Institute of Infectious Diseases, United States

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ABSTRACT

*Background:* Service members deploying to Afghanistan (OEF) and Iraq (OIF) often return with respiratory symptoms. We sought to determine prevalence of lung function abnormalities following OEF/OIF.
*Methods:* We identified OEF/OIF patients who had unexplained respiratory symptoms evaluated using lung function testing. Lung function data were summarized and analyzed for associations with demographic and deployment characteristics.
*Results:* We found 267 patients with unexplained cough or dyspnea, lung function testing and a history of OEF/OIF deployment. All patients had basic spirometry performed and 82 had diffusion capacity for carbon dioxide (DLCO) measured. The median (IQR) number of deployments and total days deployed were 1 (1–2) and 352.0 (209–583), respectively. There were 83 (36.6%) patients with abnormal spirometry, 53 (63.9%) of whom had an abnormal $FEV_1/FVC$. Only one (1.2%) patient had an abnormal DLCO adjusted for alveolar volume. Of 104 patients who had post bronchodilator (BD) testing performed, six (5.8%) had a positive response by ATS criteria. We found no relationships between lung function and time in theater, deployment location, deployment frequency, or land based-deployment. Dyspnea and enlisted rank were associated with tobacco use and lower FEV1, and cough was associated with total number of deployments.
*Conclusions:* Service members with respiratory complaints following OEF/OIF have a high prevalence of abnormalities on spirometry. Tobacco use, enlisted rank and total number of deployments were associated with symptoms or spirometric abnormalities.

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## 1. Introduction

Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF) began in Afghanistan and Iraq more than ten years ago. During OEF/OIF deployment as many as 69.1% of service members will be diagnosed with a respiratory illness [1]. Both asthmatics and non-asthmatics will experience a significant increase in respiratory symptoms [2], and deployers experience increased rates of dyspnea, shortness of breath and asthma when compared to non-deployers [3,4].

Deployment related respiratory complaints are likely a manifestation of different exposures and disease processes expected to have variable effects on lung function testing [5–7]. Studies on

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* Corresponding author.
*E-mail addresses:* aholley9@gmail.com (A.B. Holley), sobiemj@gmail.com (M. Sobieszczyk), Michael.perkins321@gmail.com (M. Perkins), Brian.m.cohee.mil@mail.mil (B.M. Cohee), Camille.b.costantoth.mil@mail.mil (C.B. Costantoth), Donovan.l.mabe.mil@mail.mil (D.L. Mabe), Robert.A.Liotta.mil@mail.mil (R. Liotta), joseph.h.abraham.civ@mail.mil (J.H. Abraham), HolleyPR@msn.com (P.R. Holley), John.H.Sherner.mil@health.mil (J. Sherner).

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**Abbreviations**

| | |
|---|---|
| ATS | American Thoracic Society |
| BD | Bronchodilator |
| CP | Cardiopulmonary |
| DLCO | diffusion capacity for carbon monoxide |
| EMR | electronic medical record |
| EVH | eucapneic voluntary hyperventilation |
| FBCH | Fort Belvoir Community Hospital |
| $FEV_1$ | forced expiratory volume in one second |
| $FEV_3$ | forced expiratory volume in three seconds |
| FVC | functional vital capacity |
| IQR | inter-quartile range |
| KCO | DLCO/VA, also known as the transfer factor for carbon monoxide |
| LLN | lower limit of normal |
| NHANES III | Third National Health and Nutrition Examination Survery |
| NOS | Not otherwise specified |
| NS | Non-smoker |
| OEF | Operation Enduring Freedom |
| OIF | Operation Iraqi Freedom |
| PE | Pulmonary Embolism |
| PFT | Pulmonary function testing |
| PM | Particulate matter |
| S | Smoker |
| SWA | South West Asia |
| USAPHC | U.S. Army Public Health Command |
| VA | alveolar volume |
| WRNMMC | Walter Reed National Military Medical Center |

post-deployment spirometry and diffusion capacity (DLCO) have been limited by small sample sizes [8,9], confinement to predominantly one particular unit/location [9] or the absence of detail on deployment, demographics and reference ranges [10]. We analyzed data from a large group of service members with unexplained respiratory symptoms following deployment to quantify associations between lung function and demographic/deployment characteristics.

## 2. Methods

This study is a retrospective review of patients referred to the pulmonary clinics at Walter Reed National Military Medical Center (WRNMMC) and Fort Belvoir Community Hospital (FBCH) from February 2012 through May 2013. All patients were referred for unexplained respiratory complaints and had at least one spirometry test performed following deployment in support of OEF/OIF.

### 2.1. Reference values for interpretation of spirometry, DLCO and lung volumes

All testing was conducted using Sensormedics Pulmonary Function Testing Equipment (Carefusion, Yorba Linda, CA). Spirometry and bronchodilator (BD) testing were performed according to American Thoracic Society (ATS) standards [11], as was DLCO [12]. Data from NHANES III [13] was used for interpretation of pre-BD spirometry in African Americans (AA), Caucasians and Hispanics. Reference equations by Kolotzer et al. were used to establish normal values for Asians. Reference values for $FEV_3$/FVC and DLCO were taken from Hansen et al. [14] and Miller et al. [15] respectively. DLCO was also examined using the equations from Crapo et al. [16] to facilitate comparison with other studies [8,9,17]. BD testing was considered positive if either $FEV_1$ or FVC were increased by > 200 cc and >12% in comparison to baseline [18,19].

### 2.2. Statistics

Normally and non-normally distributed variables are displayed by mean ± standard deviation and median with intra-quartile range, respectively. Comparisons between continuous variables were made using the independent samples *t*-test and the Mann-Whitney *U* test for normally and non-normally distributed variables, respectively. Bivariate correlations were assessed using Spearman's correlation coefficient. All data analysis was performed using SPSS 21.0 (Chicago, IL).

## 3. Results

Demographics and symptoms for the 267 patients who met our inclusion criteria are listed in Table 1. The median number of deployments and total days deployed were 1.0 (1.0–2.0) and 352.0 (209.0–583.0) respectively. The median time since the most recent deployment was 27.9 (13.1–55.2) months. Table 2 shows results for spirometry and DLCO. When the Crapo [16] equations were used as the reference standard instead of Miller, the mean percentage predicted DLCO was 73.2 ± 12.1% and 53/83 (63.9%) were below the 5th percentile. Among those with abnormal DLCO according to Crapo, reductions were mild, moderate and severe in 33 (62.3%), 4 (7.5%) and 16 (30.2%) patients respectively and KCO was abnormal in 22 (26.5%). There were 104 patients who had bronchodilator (BD) testing performed and only 6 (5.8%) had a positive response by ATS criteria. Of the 65 patients with abnormal spirometry at baseline, 6 (7.2%) had a BD response. Table 3 shows relationships between spirometry, cough, tobacco use and dyspnea. Cough and dyspnea were associated with spirometric abnormalities, whereas tobacco users had a higher rate of dyspnea.

Mean PPD values for $FEV_1$, FVC, $FEV_1$/FVC, $FEV_3$/FVC, DLCO and KCO were not significantly different for the following comparisons: deployed to Afghanistan versus those who did not, deployed to Iraq versus those who did not, Guard/Reserves versus Active Duty or land versus air/sea based deployment (appendix 1). Enlisted service members had lower mean values for FEV1 and FVC when compared to officers (appendix 1). Total number of deployments, total days deployed and months since the most recent deployment were not related to any lung function values (appendix 2). Patients with cough had more total deployments (2.0 (1.0–2.0) versus 1.0 (1.0–2.0); $p = 0.01$), but patients with dyspnea did not. Neither symptom was related to total days deployed or months since most

**Table 1**
Demographics and symptoms.

| | |
|---|---|
| Age | 36.3 ± 9.8 |
| BMI | 28.2 ± 4.3 |
| Male | 207/267 (77.5%) |
| Race | |
| Caucasian | 146/267 (55.3%) |
| African American | 73/267 (27.7%) |
| Hispanic | 36/267 (13.6%) |
| Asian | 9/267 (3.4%) |
| Tobacco Use (ever) | 91/267 (34.1%) |
| Dyspnea | 209/267 (78.3%) |
| Cough | 118/267 (44.2%) |