Training and Health Outcomes of Women Diagnosed with Iron Deficiency Anemia During Basic Military Training

Col Candy Wilson
Ms. Amy Lynn

FINAL REPORT

Date: 10 Jan 2022

59th Medical Wing
Office of the Chief Scientist
1632 Nellis, BLDG. 5406
JBSA Lackland, TX 78236-7517

DECLARATION OF INTEREST

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Air Force, Department of Defense, nor the U.S. Government. This work was funded by Project Code Number AC12EM01. Authors are military service members, employees, or contractors of the US Government. This work was prepared as part of their official duties. Title 17 USC §105 provides that 'copyright protection under this title is not available for any work of the US Government.' Title 17 USC §101 defines a US Government work as a work prepared by a military service member, employee, or contractor of the US Government as part of that person's official duties.

NOTICE AND SIGNATURE PAGE

STUDY TITLE

The Evaluation of a Clinical Practice Guideline for Sustaining Iron Status in Female Warriors

Ruben O'Neal III, MPA, DAF
Program Analyst
59MDW Office of the Chief Scientist

Candy Wilson, Col, USAF, NC
Associate Professor, Graduate School of Nursing
Uniformed Services University of the Health Sciences
59MDW Office of the Chief Scientist

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE	**2. REPORT TYPE**	**3. DATES COVERED**
Jan 10, 2022	Final Report	2 Aug 2016-30 Sep 2021

4. TITLE AND SUBTITLE

Study Title: Training and Health Outcomes of Women Diagnosed with Iron Deficiency Anemia During Basic Military Training

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Candy Wilson, Col, USAF, NC
Amy Lynn, DNP Student, The University of Texas at Austin School of Nursing

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
United States Air Force, 59th Medical Wing (59MDW/ST).
1255 Wilford Hall Loop, Building 4430
Lackland Air Force Base, 78236-9980

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A: Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT-

Female trainees are at increased risk for iron deficiency (ID) and iron deficiency anemia (IDA) because of their age and the physical demands of basic training (Wilson & Brothers, 2010). While current hereditary or acquired anemia is listed as a disqualifying medical condition (DODI 6130.03, Volume 1) and the Accessions Medical History Report (DD From 2807-2) requires providers to document a history of anemia, people considered for military service are not tested for current anemia (USMEPCOM Regulation No. 40-1). ID and IDA cause a host of adverse outcomes such as diminished work capacity and endurance (Haas & Brownlie, 2001; DellaValle, 2013), diminished immune function (Gleeson, Nieman & Pedersen, 2004), and neurocognitive impairment (Clark, 2008; Murray-Kolb & Beard, 2007) all of which directly affect successful completion of initial military training and overall military readiness.

15. SUBJECT TERMS- iron deficiency anemia, training, military women

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT:**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Col Candy Wilson
U	U	U	UU	17	**19b. TELEPHONE NUMBER** *(include area code)* 301-295-1468

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

Female trainees are at increased risk for iron deficiency (ID) and iron deficiency anemia (IDA) because of their age and the physical demands of basic training (Wilson & Brothers, 2010). While current hereditary or acquired anemia is listed as a disqualifying medical condition (DODI 6130.03, Volume 1) and the Accessions Medical History Report (DD From 2807-2) requires providers to document a history of anemia, people considered for military service are not tested for current anemia (USMEPCOM Regulation No. 40-1). ID and IDA cause a host of adverse outcomes such as diminished work capacity and endurance (Haas & Brownlie, 2001; DellaValle, 2013), diminished immune function (Gleeson, Nieman & Pedersen, 2004), and neurocognitive impairment (Clark, 2008; Murray-Kolb & Beard, 2007) all of which directly affect successful completion of initial military training and overall military readiness.

The purpose of this retrospective case-comparison study was to determine the effects of IDA on training and health outcomes of women in basic military training. Health and training records were reviewed for all women who entered US Air Force BMT from 01 May 2018 through 31 Oct 2019. During this period, compared the health and training data of 170 women diagnosed with IDA by a health care provider to 170 women who had no anemia diagnosis. The case was matched to the control by age, height, weight, ethnicity (when available), and week of training. It was determined that women with IDA experienced health decrements that negatively impacted their training outcomes. Fitness tests were compromised by reduced run times ($p < .001$) and physical training, $\chi^2(1) = 22.31$, $p < .0001$. These fitness factors improved over time, but did not reach the level of trainees without IDA who scored higher during their initial test. There were no statistical differences between groups for sit up. However, there were small differences in pushups between groups, though still passing the fitness test scores.

Graduation timing was determined to be significantly different between groups where 80.3% of trainees with IDA and 95.9% of trainees without IDA graduated on time. Of greater concern is the timing of graduation given follow-on training is dependent upon. Only 48.44% of the IDA group graduated on time, while 88.75% of the Non-IDA group graduated on time ($\chi^2(1) = 120.70$, $p < .0001$). The main reasons for attrition in the Non-IDA group were administrative/erroneous discharge ($n = 4$) and fraudulent enlistment ($n = 4$). The primary reason for attrition in the IDA group was medical discharge ($n = 48$). A possible contributing factor to medical discharge or late graduation is the physiologic connection between IDA and stress fractures. It was found that Musculoskeletal (MSK) conditions occurred with significantly greater frequency in the IDA group ($n = 12$ cases) than the Non-IDA group ($n = 4$ cases) ($p = 0.07$). When looking at MSK related pain (ICD-10 codes M25.5 or M79.6) as a primary diagnosis, there was no significant difference between groups ($\chi^2(1) = 1.54$, $p = 0.22$). The IDA group (median hours = 21.4) had a significantly greater amount of time out of training for medical care than the Non-IDA group (median hours = 8.7) ($p<.0001$).

Important to graduation is the end of course examination. There was not meaningful difference in the end of course test scores, though statistically significant ($\chi^2(1) = 0.54$, $p = 0.46$).

The total healthcare cost for the IDA group (median = $2,304) was significantly higher than that of the Non-IDA group (median = $513) ($p <.0001$). The outpatient cost for the IDA group

(median = $2,304) was significantly higher than the one for Non-IDA group (median = $513) (p <.0001).

Through this retrospective project, we found that IDA can reduce the pipeline of on-time and fully physically fit trainees. It would suggest that evaluating the health of women in training must include consideration and even screening for IDA before training. Future work should consider the outcomes of screening before enlistment at MEPS and at arrival to BMT. This screening can inform women about their health and

2.0 INTRODUCTION

According to Duffin (2021), in 2019, the Department of Defense's total active duty component consisted of 1.3 million members. Of this, women comprise 17% of the United States (US) military and are increasing in numbers since the 2016 recension of the combat exclusion policy that resulted in additional military career possibilities for women (U.S. Government Accountability Office). According to the Council of Foreign Relations (2020), specifically in the United States Air Force, female officers account for 21% and female enlistments account for 20% of the total force. During the recruitment phase prior to enlistment into the US military, accession policies enforce specific age and health restrictions. Female recruits typically range from 17-28 years old, are premenopausal, non-pregnant, and free of chronic diseases (Office of the Under Secretary of defense for Personnel and Readiness, 2020). Consequent to these policies, the vast majority of military women have natural childbearing potential and by virtue of regular menstruation are at risk for iron deficiency (ID) and iron deficiency anemia (IDA).

Female trainees are at increased risk for ID and IDA because of their age and the physical demands of basic training (Wilson & Brothers, 2010). Much of what is known about iron status in training has been drawn from the research of iron status and its effect on performance in elite professional and non-professional female athletes. ID and IDA cause a host of adverse outcomes such as diminished work capacity and endurance (Haas & Brownlie, 2001; DellaValle, 2013), diminished immune function (Gleeson, Nieman & Pedersen, 2004), and neurocognitive impairment (Clark, 2008; Murray-Kolb & Beard, 2007) all of which directly affect successful completion of initial military training and overall military readiness. Causal links between ID and IDA, decreased aerobic capacity and work performance have been reported for over a decade with far reaching economic and safety implications (Haas & Brownlie, 2001; Brownlie, Utermohlen, Hinton, Haas, 2004).

Following accession into US military services, all recruits undergo an intense and physically demanding training program ranging from four to 13 weeks duration, designed to develop the necessary level of fitness and endurance to perform strenuous mission-related duties. Table 1 depicts initial military training requirements for each of the Services. In addition to the physical components listed, Coast Guard trainees must also tread water for five minutes, jump from a 6-foot platform and swim 100 meters, and complete a sit-and-reach test. Marine Corps recruits can choose push-ups or pull-ups and sit-ups or a timed plank. At this time, Space Force enlistees attend Air Force basic training. All train to the same physical requirements.

Inability to physically perform due to decreased aerobic capacity or injuries can lead to attrition from physically demanding military training. US Air Force Basic Military Training (BMT)

population health leaders have noted that female recruits at BMT have had double the attrition rate of male recruits and four times the rate of injuries as their male counterparts (personal communication Maj Mary Pawlak, 14 Apr 2021). Females in Army Basic Combat Training (BCT) incurred double the injuries than males (Bell, Mangione, Hemingway, Amoroso, and Jones, 2000) A study of Army recruits in BCT found the most common injuries were musculoskeletal and occurred in up to 50% of females (Malloy, Feltwell, Scott, and Niebuhr, 2012). This study also identified female sex as the number one risk factor for sustaining any injury.

Female military members present physiologic differences that directly impact performance and need to be targeted for specific interventions to promote safety and enhance force multiplying potential (McClung, Karl, Cable, 2009; Wilson, McClung, Karl, and Brothers, 2011). Iron deficiency was found to be one of the predictors for stress fractures in female Israeli military recruits (Moran, Israeli, & Evans, 2008; Yanovich, Merkel, Israeli, Evans, Erlich, and Moran, 2011). In one of the few longitudinal cohort studies of female soldiers before and after BCT, McClung et al (2009) found compelling evidence of diminished iron status predictive of impaired aerobic performance.

The DoD's United States Military Entrance Processing Command (USMEPCOM) determines whether applicants are qualified for military service based on standards set by each of the Services. Prior to attending training, recruits must complete a medical history form, provide medical records, and undergo a physical examination as part of the USMEPCOM Medical Qualification Program (UMQP). While current hereditary or acquired anemia is listed as a disqualifying medical condition (Office of the Under Secretary of Defense for Personnel and Readiness, 2021) and the Accessions Medical History Report, DD From 2807-2, asks about a history of anemia, people considered for military service are not screened for current anemia (USMEPCOM Regulation No. 40-1).

3.0 METHODS, ASSUMPTIONS AND PROCEDURES

The purpose of this retrospective case-comparison study was to determine the effects of IDA on training and health outcomes of women in basic military training. Health and training records were reviewed for all women who entered US Air Force BMT from 01 May 2018 through 31 Oct 2019. Cases were defined as those who received a new ICD-10 diagnosis of iron deficiency anemia while at BMT. IDA cases were then matched 1:1 to women without a diagnosis of any type of anemia, on the basis of age, week of entry into training, service component, and race/ethnicity.

AIM 1: Determine the difference, if any, in physical fitness test performance between the two groups.

Physical fitness was assessed by comparing performance on three Air Force Physical Fitness Test components: 1.5 mile run, 1 minute of push-ups, and 1 minute of sit-ups at three time points—initial testing done close to the start of training, testing during week 3 of training (3WOT), and the final fitness test needed to graduate.

AIM 2: Compare the on-time graduation rate between the two groups.

For the women who graduated, we evaluated whether they graduated on time. If they did not, we calculated the number of days they remained at training past the expected 57 days. We also investigated attrition rates.

AIM 3: Compare the test scores on the End of Course (EOC) written exam between the two groups.

Trainees are required to pass a written EOC examination in order to graduate. This test score was used to assess cognitive function.

AIM 4: Determine the association of IDA with the diagnosis of comorbid musculoskeletal (MSK) conditions.

We revised the medical records for the presence of ICD-10 codes for stress fracture (overuse injury) and bone or joint pain.

AIM 5: Compare the amount of time the trainees with IDA spend out of training for medical purposes (unsafe to train, convalescence, medical appointments, etc.) to trainees not diagnosed with IDA.

Two variables were investigated to calculate time out of training. Firstly, we reviewed the Charge of Quarters (CQ) logs to see when trainees signed out of and then back into the unit. The duration of absence was recorded if 1) the trainee was noted to be departing for a medical treatment facility and 2) the trainee was not listed as an escort for another trainee. Secondly, we calculated the amount of time the trainee remained on Medical Holdover status, meaning the trainee was reassigned to a non-training squadron to allow for medical assessment, convalescence, and/or administrative processing related to a medical condition.

AIM 6: Determine the training costs associated with IDA.

Training costs were calculated from the accession cost (cost to recruit, medically qualify, and ship a trainee to BMT) and the daily training cost, both provided by BMT personnel, and the attrition rate and the number of days the trainees remained at BMT.

AIM 7: Determine the healthcare costs associated with IDA.

Healthcare costs were provided by the Defense Health Agency (DHA), as part of the data extract from the electronic heath record.

4.0 MAJOR EVENTS/MILESTONES/SUCCESS

In preparation for the execution of this project,

- Kick Off Meeting – Aug 2017
- Institutional Review Board Approval – 7 Mar 2020
- All experimental procedures completed – n/a
- Data Analysis – 30 Sept 2020
- Present to 559 MDG Leadership – 07 May 2021
- Poster presentation – 2021 at Uniformed Services University of the Health Sciences Research Days (virtual)
- Podium presentation – 10 June 2021 at San Antonio Military Health System and Universities Research Forum (virtual)
- Manuscript submitted to – name of journal and date: TBD
- Dissemination of Results – Conference attendees asked many questions about the findings and the follow-on project.

5.0 RISK ASSESSMENT

5.1 Risk Analysis

This study was originally planned and funded to collect data when implementing an investigator-developed clinical practice guideline to screen for iron deficiency and iron deficiency anemia. Several contracting issues halted this plan and delayed this project by three years. This original project was approved by the 59 MDW Institutional Review Board as "not research" on 21 April 2017.

5.2 Technical Challenges

None

6.0 TRANSITION PLAN

6.1 Military Relevance

It was determined that women with IDA experienced health decrements that negatively impacted their training outcomes. Evaluating the health of women in training must include consideration of and even screening for IDA before training. It is logical to apply these findings to other physically intense training environments. Women who have a history of anemia, menstrual irregularities, not using hormonal contraception are at greatest risk fir IDA should be evaluated before training or deployments (Wilson, McClung, Karl, & Brothers, 2011).

6.2 Transition Strategy

The project findings inform Department of Defense Instruction (DoDI) 6130.03, *Medical Standards for Appointment, Enlistment, or Induction into the Military Services*. At present, section 5.22 (a) states that any current hereditary or acquired anemia is disqualifying for military service. However, in practice, the disqualification can be waived depending on the severity of the

iron deficiency and the response to treatment. The findings of this project will be important for informing future versions of this DoDI, with the plan to incorporate the iron deficiency screening protocol at Military Entrance Processing Stations (MEPS).

Trainee health professionals offer multivitamins to women in training. This helps to reduce any progression of IDA. However, multivitamins will take approximately 4-6 weeks to improve iron status for women with mild IDA. The goal of screening prior to entry into training is to identify women with iron deficiency or mild anemia that is treatable with conservative treatments. This would allow for correction of the condition prior to the initiation of training, leading to improved military training outcomes. Conversely, the screening will identify women who are severely anemic and ensure appropriate medical referrals to identify the source of the anemia. The outcomes of this project support the DoD integration of women by providing evidence that intervening early in this generally treatable medical outcome will promote success in training, thereby improving the numbers of military women.

None of the military services screen recruits for anemia (M. Termini, personal communication, February 12, 2020), and only the Army and Air Force offer supplemental iron (in the form of a multivitamin) to incoming female trainees (J. McClung, personal communication, February 25, 2020). The findings of this project will inform all military service training commands of the impact of iron deficiency anemia on trainee performance and the association with training outcomes of women. As part of the full-integration of women, it is important for all services to be informed of the findings to appropriately screen for this treatable condition. Therefore, findings will be shared with the services through the training command leadership and the DHA-Women's Health Research Interest Group. The institutional review board approved storage of the data from this project in a repository database that can be queried for other research questions.

Colonel Wilson has a Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) project funded through US Army Medical Research & Development Command. The grant has funded two industry partners in the development of point-of-care, handheld devices to test for iron deficiency and iron deficiency anemia. These devices use less than 1 mL of serum specimen and diagnostic information in less than 15 minutes. This rapid diagnostic response assists health care personnel in the trainee health clinic to treat military trainees in a shortened time frame. The SBIR devices just completed Phase II development. The ultimate goal is to provide this device to MEPS and basic training clinics. The early identification of women with iron deficiency or iron deficiency anemia will provide health care providers the opportunity to intervene and educate women about their individual nutrition needs while in training. We have presented a previous analysis that demonstrated the cost-effectiveness of screening for iron deficiency based on Myhre, et al (2016) findings and trends reported by the Trainee Health Surveillance team (personal communication, Dr. Thomas Cropper).

The project did not develop intellectual property that will require technology transfer agreements. Key stakeholders at the Centers for Disease Control and Prevention (CDC) and the National Heart, Lung, and Blood Institute (NHLBI) have expressed interest in this study and iron

status screening in training populations. Even though these findings are not necessarily be generalizable, these findings will be informative to the military training health care leaders.

7.0 RESULTS

A total of 320 women were diagnosed with IDA during the retrospective study time frame. Table 2 shows there were no significant differences between the those with IDA and their matched comparisons in terms of age, height, weight, or body mass index. There was a significant difference between groups for the elevation of home of record; women without anemia had a median elevation that was higher (533 ft) than women with anemia (267 ft).

Aim 1: Fitness Test Comparison

Table 3 shows the differences in the run time between IDA and Non-IDA groups were statistically significant at all three times (i.e., Initial, 3rd week of training [3WOT], Final): The non-IDA group had significantly faster run times than the IDA group ($p < .0001$). Both groups improved run times as training continued; however, the differences between the two groups narrowed as training continued. The number of push-ups performed by the Non-IDA group at 3WOT and at the final test were significantly greater than the ones performed by the IDA group ($p = 0.02$). No significant differences were found in the sit-up component.

For the IDA group, the reductions in run times at from Initial to 3WOT (median = -70.80) and from Initial to Final test (median = -146.30) were significantly greater than the reductions for the Non-IDA group (-54.15 at 3WOT and -95.00 at Final).

At the initial test, the pass rate for the Non-IDA group was 77.35%, while the pass rate for the IDA group was 59.45% ($\chi^2(1) = 22.31$, $p <.0001$). At 3WOT, the pass rate for the Non-IDA group was 89.14%, and the pass rate for IDA group was 62.50% ($\chi^2(1) = 58.43$, $p <.0001$). At the final test, the pass rate for the Non-IDA group was 97.06%, while the pass rate for the IDA group was 90.55% ($\chi^2(1) = 10.85$, $p = .001$).

Oxygen Consumption

VO_2 max is an indicator of cardiovascular fitness and aerobic endurance. Given the known run course distance of 1.5 miles, we were able to calculate the VO_2 max from the run times. Higher VO_2 max was noted at each of the three time points for the non-IDA group, as depicted in Figures 1-3.

Aim 2: Graduation Outcomes

The graduation rates were 80.31% and 95.94% for the IDA and Non-IDA groups, respectively. Only 48.44% of the IDA group graduated on time, while 88.75% of the Non-IDA group graduated on time ($\chi^2(1) = 120.70$, $p <.0001$). The main reasons for attrition in the Non-IDA group were administrative/erroneous discharge (n = 4) and fraudulent enlistment (n = 4). The primary reason for attrition in the IDA group was medical discharge (n = 48).

The total medication cost for the IDA group (median = $129) was significantly higher than the Non-IDA group (median = $99) (p = 0.0004). 18.1% (n = 59) of the IDA group and 10% (n = 32) of the Non-IDA group had active prescriptions for an oral contraceptive pill; there was no significant difference in the cost of these contraceptives (p = 0.49). Of 320 IDA group trainees, 308 (96%) filled an iron medication prescription; the total cost for iron supplementation for in the Iron group was $4,775.71. Of 320 IDA group trainees, 308 (96%) had taken the iron medication, and the average cost for iron was $15.51. No significant difference in the cost for birth control was found (p = 0.88).

Timing of Iron Medication and Performance

The median time from entry into training to initiation of iron supplementation was 12 training days (IQR: 6.50 – 29.00; n = 308). Table 6 shows there was a significant positive correlation between the duration of iron supplementation and run time improvement; the greatest improvement was seen between Initial and 3WOT tests (rho = .15, p = 0.013). No significant relationships were found between the training day on which iron was dispensed and changes in performance on the sit-up and push-up components of the fitness test.

Women with untreated IDA (n = 9) were 43% less likely to pass the final test compared to women receiving iron therapy on or before training day 21 (n = 172), but pass rate differences were not significant (p = 0.62). Women receiving therapy after training day 21 were 58% less likely to pass than women receiving therapy earlier; pass rate differences were significant (p = 0.04). This demonstrates the earlier women are treated, the better their final run time.

Aim 3: Cognitive Performance

The difference in end-of-course (EOC) test score for the IDA group (median = 85.0; IQR: 80.0-90.0) and the Non-IDA group (median = 86.0; IQR: 82.0-90.0) was statistically significant, but not practically meaningful. The EOC pass rate for IDA group was 97.13% and the pass rate was 98.06% in the Non-IDA group ($\chi^2(1) = 0.54$, p = 0.46).

Aim 4: Association with Musculoskeletal Conditions

Musculoskeletal (MSK) conditions occurred with significantly greater frequency in the IDA group (n = 12 cases) than the Non-IDA group (n = 4 cases) (p = 0.07). When looking at MSK related pain (ICD-10 codes M25.5 or M79.6) as a primary diagnosis, there was no significant difference between groups ($\chi^2(1) = 1.54$, p = 0.22).

Aim 5: Time Out of Training

The IDA group (median hours = 21.4) had a significantly greater amount of time out of training for medical care than the Non-IDA group (median hours = 8.7; p<.0001). Time out of training data are depicted in Table 4.The median medical hold days were analyzed separately from the time out of training for medical care. Medical hold days for the IDA group (n = 96) and Non-IDA group (n = 23) were 31 and 23, respectively (p = 0.10).

Aim 6: Training Cost

The training costs we calculated represent spending in excess of the amount needed to recruit and train a woman who graduates on time. The cost of attrition by members of the IDA group was $3,218,947.26, compared to $603,600.68 in the Non-IDA group. Delayed graduation accounted for $1,315,945.92 additional spending in the IDA group and $171,411.18 in the Non-IDA group. The total training cost due to attrition and delayed graduation was $4,534,893.18 in the IDA group and $775,011.86 in the Non-IDA group.

Aim 7: Healthcare Cost

Healthcare expenditures are shown in Table 5. The total healthcare cost for the IDA group (median = $2,304) was significantly higher than that of the Non-IDA group (median = $513) (p <.0001). The outpatient cost for the IDA group (median = $2,304) was significantly higher than the one for Non-IDA group (median = $513) (p <.0001). Even though spending on inpatient services was 9 times higher for the IDA group (n=18) than the non–IDA group (n=2), there was no significant difference in cost for inpatient treatment (p=0.75).

8.0 CONCLUSION/DISCUSSION

In this retrospective cohort matched study of 640 women in US Air Force basic military training, there were statistically significant differences between women with IDA and women without an IDA diagnosis when we assessed run score, time out of training, and graduation on time. We found 2.2% of the population at the time when these data were captured were diagnosed by a health care provider with anemia. This is contrary to published findings from the same population; when all were screened for IDA, 25% had the laboratory features of anemia (Myhre). Researchers at an Army basic combat training site found 16% of women recruited for an iron supplementation study were diagnostic for IDA (McClung et al., 2009). Not only does the military have to consider the health and performance of the woman in the military through additional screening that provides options for early intervention to improve outcomes and cost, but also any possible children born while the woman is anemic.

Among the 97.6% of military women who are of childbearing potential in 2016, 13.6% had at least one pregnancy-related event during that year (Stahlman, Witkop, Clark& Taubman, 2017). All women in Air Force military training are given a bottle of (PNV or MVI) at the start of training. Barnes et al. (2015) found that PNV are preferred for the following reasons: (1) the relative low daily cost of $0.03 being on the formulary whereas MVI are not, (2) meeting the standard of the Institute of Medicine's (now the National Academy of Medicine) recommended intake of 22 milligrams per day of iron for those in military training, and (3) contain the recommended daily dose of folic acid 0.4 – 0.8 milligrams per day by the U.S. Preventative Services task Force for women during child bearing age (p.554).

9.1 Publications

None to date

9.2 Presentations

9.2.1 Poster presentation:

9.2.2 Podium presentation:

Wilson C. (2019). *Cost-effectiveness of iron screening for military women in training.* TriService Nursing Research Program Dissemination Course. San Diego, CA

Wilson C. & Gardner, C. (2021). *Training and health outcomes of women diagnosed with iron deficiency anemia during basic military training*. Uniformed Services University of the Health Sciences Research Days, Bethesda, MD (virtual).

Lynn, A. B. (2021, June 10). *Training and health outcomes of women diagnosed with iron deficiency anemia during basic military training* [Conference session]. San Antonio Military Health System and Universities Research Forum, Virtual Event.

10.0 COST

$1,105,000 received from JPC-5 for project.

11.0 REFERENCES

Barnes, K. R., Tchandja, J. N., Webber, B. J., Federinko, S. P., & Cropper, T. L. (2015). *The effects of prenatal vitamin supplementation on operationally significant health outcomes in female Air Force trainees*. Military Medicine 180(5) 554-558. https://doi.org/10.7205/MILMED-D-14-00258

Bell NS, Mangione T, Hemingway D, Amoroso PJ, Jones BH. High injury rates among female army trainees: A function of gender? Am J Prev Med 2000;18:141-6.

BrownlieIV T, Utermohlen V, Hinton PS, Haas JD. Tissue iron deficiency without anemia impairs adaptation in endurance capacity after aerobic training in previously untrained women. The American Journal of Clinical Nutrition 2004;79:437-43.

Clark SF. Iron deficiency anemia. Nutrition in Clinical Practice 2008;23:128-41.

Council on Foreign Relations (2020, July 13). *Demographics of the U.S. Military.* https://www.cfr.org/backgrounder/demographics-us-military

DellaValle DM. Iron supplementation for female athletes: effects on iron status and performance outcomes. Current sports medicine reports 2013;12:234-9.

Duffin, E. (2021, November 9). Active duty U.S. Department of Defense personnel numbers from 1995 to 2020. Statista. https://www.statista.com/statistics/232350/us-department-of-defense-personnel-numbers/

Gleeson M, Nieman DC, Pedersen BK. Exercise, nutrition and immune function. Journal of Sports Sciences 2004;22:115–25

Haas JD, T. Brownlie I. Iron deficiency and reduced work capacity: A critical review of the research to determine a causal relationship. Journal of Nutrition 2001;131:676S-90S.

McClung JP. Iron status and the female athlete. Journal of Trace Elements in Medicine and Biology 2012;26:124-6.

McClung JP, Karl JP, Cable SJ, Williams KW, Young AJ, Lieberman HR. Longitudinal decrements in iron status during military training in female soldiers British Journal of Nutrition 2009;102:605-9.

McClung JP, Karl JP, Cable SJ, et al. Randomized, double-blind, placebo-controlled trial of iron supplementation in female soldiers during military training: effects on iron status, physical performance, and mood. Am J Clin Nutr 2009;90:124-31.

Molloy JM, Feltwell DN, Scott SJ, Niebuhr DW. Physical training injuries and interventions for military recruits Military Medicine 2012;177:553-8.

Moran DS, Israeli E, Evans RK, et al. Prediction model for stress fracture in young female recruits during basic training. Medicine and Science in Sports and Exercise 2008;40:S636-S44.

Murray-Kolb LE, Beard JL. Iron treatment normalizes cognitive functioning in young women. The American Journal of Clinical Nutrition 2007;85:778-87.

Office of the Under Secretary of Defense for Personnel and Readiness (2021, April 30). *Medical Standards for Military Service: Appointment, enlistment, or induction.* *https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/613003v1p.pdf?ver=2020-09-04-120010-087*

Peeling P. Exercise as a mediator of hepcidin activity in athletes. Eur J Appl Physiol 2010;110:877-83.

U.S. Government Accountability Office. (2020, May 19). *Female active-duty personnel: Guidance and plans needed for recruitment and retention efforts.* https://www.gao.gov/products/gao-20-61

Wilson C, McClung JP, Karl JP, Brothers MD. Iron status of military personnel deployed to Afghanistan. Military Medicine 2011;176:1421-5.

Yanovich R, Merkel D, Israeli E, Evans R, Erlich T, Moran DS. Anemia, iron deficiency, and stress factures in female combatants during 16 months Journal of Strength and Conditioning Research 2011;25:3412-21.

12. TABLES AND FIGURES

Table 1

Summary of initial military training duration and fitness components

Service	Duration of training (weeks)		Run (miles)	Maximum effort (minutes)	
	Enlisted	Officer		Sit-ups	Push-ups
Air Force	8.5	5.5 or 9.5	1.5	1	1
Army	10	10	2	2	2
Coast Guard	8	4 or 17	1.5	1	1
Marine Corps	13	6 or 10	3	2	2
Navy	7	5 or 12	1.5	2	2

Note. Officer training duration varies depending on the commissioning source. Marine Corps officers complete either two non-consecutive 6-week trainings or one 10-week training. Officers commissioned directly into the Navy Reserve attend DCO School, a 12-day training.

Table 2

Comparison of group makeup

Variable	IDA group			Non-IDA group			P-value
	Median	Lower quartile	Upper quartile	Median	Lower quartile	Upper quartile	
Age (years)	19.47	18.62	21.31	19.47	18.63	21.38	0.96
Height (inches)	64.00	63.00	66.00	64.00	62.00	66.00	0.29
Weight (pounds)	137.00	125.00	153.00	139.50	124.00	153.50	0.80
BMI (kg/m^2)	23.38	21.61	25.79	23.98	21.56	25.97	0.34
Elevation of home of record (feet)	267	41	692	533	110	864	0.0001*

*statistically significant

Table 3

Physical fitness test performance

Component	IDA group			Non-IDA group			P-value
	Median	Lower quartile	Upper quartile	Median	Lower quartile	Upper quartile	
Run time (MM:SS)							
Initial	17:00*	15:30	18:26	15:02*	13:57	16:15	<.001
3WOT	15:33*	14:19	16:47	14:02*	13:09	15:03	<.001
Final	14:10*	13:17	15:01	13:15*	12:32	14:25	<.001
Push ups							
Initial	16	10	22	18	12	24	0.12
3WOT	25*	19	32	27*	21	34	0.02
Final	35*	27	42	36*	30	43	0.02
Sit ups							
Initial	26	20	36	28	21	37	0.12
3WOT	36	29	45	38	31	46	0.1
Final	46	41	54	48	42	42	0.23

*statistically significant

Table 4

Time out of training

Variable	IDA group			Non-IDA group			P-value
	Median	Lower quartile	Upper quartile	Median	Lower quartile	Upper quartile	
Time out of training (HH:MM:SS)	21:21:00*	14:37:12	30:16:12	8:42:00	4:22:48	16:13:12	<.0001
Medical hold (days)	31.0	18.5	43.5	23.0	9.0	36.0	0.10

*statistically significant

Table 5

Healthcare costs

Variable	IDA group			Non-IDA group			P-value
	Median	Lower quartile	Upper quartile	Median	Lower quartile	Upper quartile	
Outpatient	$2,303.97*	$1,420.33	$3,850.50	$512.94*	$144.79	$1,342.50	<.0001
Inpatient	$4,961.06	$4,036.72	$6,299.78	$6,048.00	$3,533.85	$8,562.99	0.75
Total medication	$128.96*	$71.68	$179.58	$99.13*	$64.42	$154.20	0.0004
Hormonal contraceptives	$56.04	$19.53	$80.65	$41.53	$20.99	$66.55	0.49

*statistically significant

Table 6

Timing of iron supplementation and performance

Group	N	Change in run time (MM:SS) Between initial test and final week of training		
		Median	Lower quartile	Upper quartile
No iron supplement	9	-01:50	-02:11	-00:25
Dispense day >21	82	-02:20	-03:25	-01:20
Dispense day ≤ 21	172	-02:37	-03:42	-01:41

Figure 1

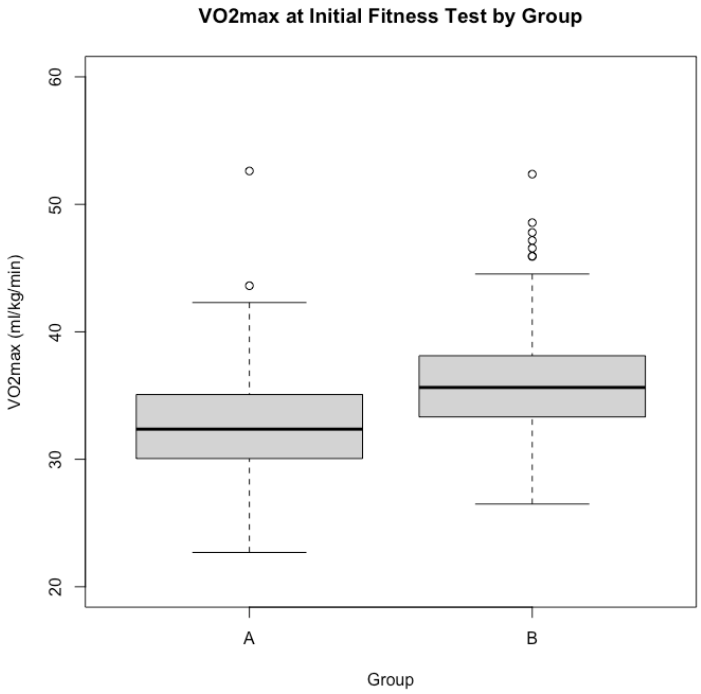


Figure 2

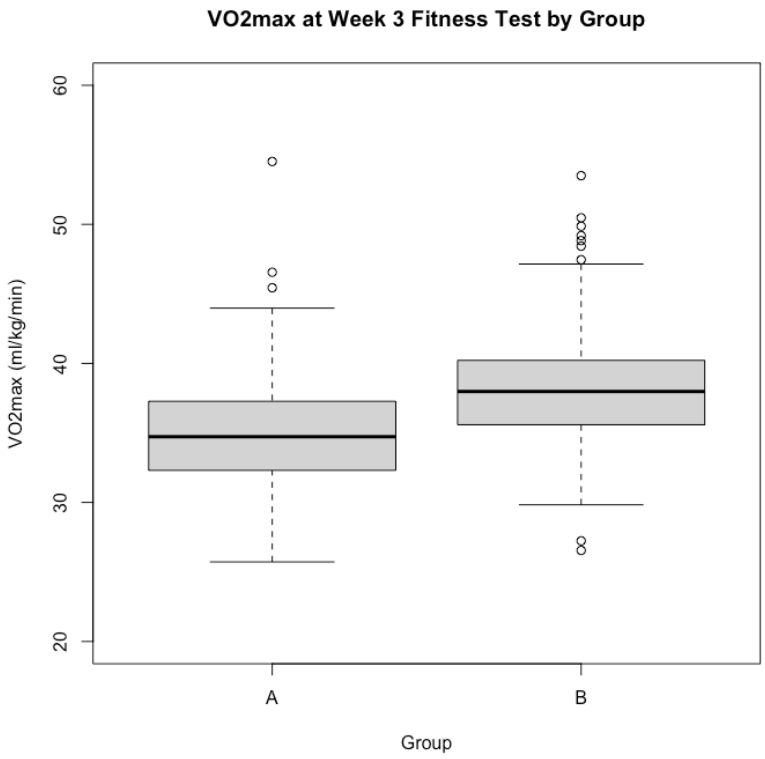
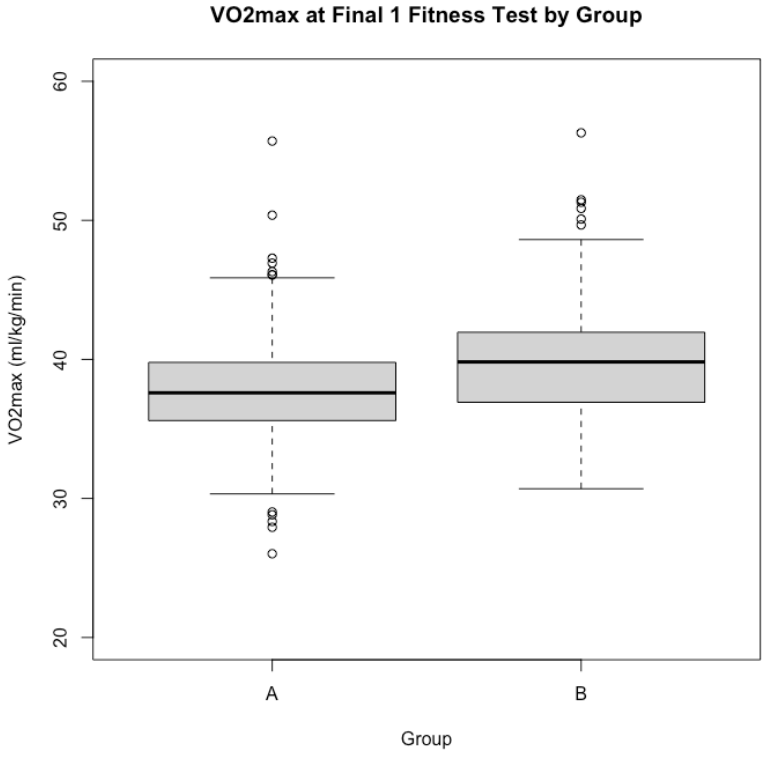


Figure 3



13.0 LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

> greater than

≤ less than or equal to

3WOT – third week of training

BCT – (Army) basic combat training

BMT – (Air Force) basic military training

CQ – charge of quarters

DCO – direct commission officer

DHA – Defense Health Agency

DoD – Department of Defense

DoDI – Department of Defense Instruction

EOC – end of course

ICD – International Classification of Diseases

IDA – iron deficiency anemia

IQR – interquartile range

kg/m^2 – kilograms per meters squared

MEPS – military entrance processing station

MSK – musculoskeletal

SBIR – Small Business Innovation Research

SBTT – Small Business Technology Transfer

UMQP – USMEPCOM Medical Qualification Program

US – United States

USMEPCOM - United States Military Entrance Processing Command

VO2/VO_2 max – volume of oxygen; the maximum volume of oxygen the body consumes