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STATEMENT OF OBJECTIVES

The Australasian Military Medicine Association is an independent, professional scientific organisation of health professionals with the objectives of:

- Promoting the study of military medicine
- Bringing together those with an interest in military medicine
- Disseminating knowledge of military medicine
- Publishing and distributing a journal in military medicine
- Promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine. The Association is totally independent of the Australian Defence Force.

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Editorial

Vaccines – The End Game?

As we go to print, Australia is preparing to roll-out the first COVID-19 vaccines by late February 2021 to various priority groups, with a second vaccine to follow in March. While there are many questions still to be answered, including how long the protection will last, whether it prevents infection, the degree of protection against serious disease in different populations and age groups, and what protection will be afforded against the new variants, including the B.1.1.7, B.1.351 and P1 lineage variants, the vaccines do provide a potential way forward for terminating the rolling outbreaks around the world, achieving some form of herd immunity and allowing a move back towards normality—the End Game.

Vaccines have played a key role in military operations since their introduction in the Great War, where typhoid vaccines were particularly effective, and further enhanced in World War 2. They remain a mainstay of military operations, including potential biological warfare threat environments in the 21st century. Vaccinating the Australian Defence Force front-line troops against COVID-19 will become a priority over the next 3–6 months, given their potential exposure during operations and possible spread to the wider Australian community.

Our first issue of 2021 contains a diverse range of articles from dental health, health and fitness training, and health promotion through to women's health. We continue to attract a good range of articles, including from overseas. We encourage all our readers to consider writing on their areas of military or veterans' health interest. We would particularly welcome papers based on our 2020 conference presentations, but welcome any articles across the broader spectrum of military health.

Dr Andy Robertson, CSC, PSM
Commodore, RAN
Editor-in-Chief

1 Shanks GD. How World War 1 changed global attitudes to war and infectious diseases. The Lancet. 2014 Nov 8;384(9955):1699-707.

2 Walker AS. Clinical Problems of War: Australia in the War of 1939-1945. Canberra: Australian War Memorial. 1962.

Short-term Influence of Garlic Supplementation Therapy on Oxidative Stress Markers Following Military Physical Activity: A Preliminary Study

R Esmaeelzadeh, K Azizbeigi, S Atashak, F Dehghan, F Feizolahi, M A Azarbayjani, Z Khojasteh

Abstract

The present study aimed to investigate the short-term influence of garlic supplementation on oxidative stress markers following military physical activity among military women. Twenty women were randomly assigned to two groups of (1) placebo (control), and (2) garlic extract supplement (experimental) along with a physical activity program. The women in the experimental group took garlic extract supplement daily for 14 days. The control group received a placebo containing 500 mg dextrose in a randomised double-blind placebo-controlled design. Blood samples were collected and analysed for plasma Malondialdehyde (MDA) and 8-hydroxy-2-deoxyguanosine (8-OHdG) before the program and 14 days after.

The results showed that military physical activity caused a significant increase in 8-OHdG and MDA (p=0.001). Hence a significant difference was found between the placebo and supplement groups in MDA (p=0.001) and 8-OHdG (p=0.001) after exercise.

It was concluded that although garlic extract could not prevent oxidative stress, it could attenuate the detrimental effects of oxidative stress among military people during physical activity.

Keywords: Antioxidant, Malondialdehyde (MDA), 8-hydroxy-2'-Deoxyguanosine (8-OHdG), Military training, Garlic

Introduction

It is almost axiomatic that physical fitness is the base of all military education. A low level of physical fitness results in unsuccessful performance in the field by military people. In contrast, good physical fitness can improve soldiers psychic resistibility for fulfilling tasks and combat actions.[1] Military programmers have designed various ways to sustain the physical fitness of military personnel. One of these is long-term military physical activity training. However, it has been reported that physical activity and exercise training, especially high-intensity and long-term, may produce free radicals and reactive oxygen species (ROS), and induce oxidative stress in the active muscles and circulation.[2] The oxidative activity of ROS is a part of the natural function of cells, but if it is repetitive, ROS can damage other cells' natural function.[3] In fact, the oxygen consumption level and metabolic rate may considerably increase during exercise.[4] This may lead to increased superoxide anion production in mitochondria and increase oxidative stress.[5] The body's antioxidant capacity is overwhelmed by the ROS enhancement in this situation. ROS contribute to fatigue because loss of function can be delayed by ROS-specific antioxidants,[6] and reduce body function. It is also thought to play an essential role in the pathophysiology of muscle damage and fatigue during activity.[7] Studies have reported that high-intensity exercise like military training pushes the lactate level beyond its threshold, leading to more oxidative stress than that caused by moderate aerobic exercise.[8] Also, it has been reported that sustained training load during the last four weeks of basic military training leads to oxidative stress observable both at rest and after submaximal exercise.[9] Some studies have reported that there is unique oxidative stress in military personnel (e.g. severe air pollution in some urban environments; radiation hazards to crew at altitude; radiofrequency radiation hazards on ships and around communications facilities; lung and tissue blast overpressure effects and physical and psychological stresses in extreme training courses)[10] that may have adverse health consequences. Some of these stresses are reasonably well characterised, such as those associated with strenuous exercise, working in the extremes of environmental temperatures, and altitude.[10]

Biological systems have both enzymatic and non-enzymatic antioxidant defences. In such situations, antioxidants protect against oxidative stress.[11] On the other hand, because of the high increase of ROS during physical activity, the antioxidant power is weakened due to oxidative stress. This makes it impossible for the cells to clear the ROS.[12] Therefore, researchers have studied a wide range of drug and non-drug antioxidant supplements, which may decrease oxidative stress.[13, 14, 15] Some previous studies have reported that the use of a nutrient and antioxidant supplement can be a proper solution to oxidative stress.[16] Besides, regular exercise enhances the body's antioxidant power.[17] However, having fewer side effects than synthetic antioxidant components, herbal antioxidants' use has received attention from several researchers.[18] Herbal treatments are getting more attention because of their easy availability, low cost and popularity among consumers.[19] Garlic (*Allium sativum L.*) originated in many regions of the world, especially western Asia and the Mediterranean coast, and has played an important role in ancient and modern medicine.[20]

Garlic contains different sulfur compounds, such as alliin and allicin, allyl disulfide, terpenes, including citral, geraniol and linalool. Scientists have attributed the antioxidant effects of garlic to thiosulfonate (allicin).[21] It has been shown that alliin can scavenge superoxide, while allicin suppresses superoxide formation by the xanthine/xanthine oxidase system. Also, alliin, allyl cysteine and allyl disulfide can all scavenge hydroxyl radicals.[22] However, apart from plasma's antioxidant power, garlic extract consumption may help ameliorate the negative effects of oxidative stress damage after strenuous exercise. This study aimed to investigate the effects of garlic extract consumption on Malondialdehyde (MDA) concentration as a lipid peroxidation, and 8-hydroxy-2'-Deoxyguanosine (8-OHdG) as a DNA damage-marker of military physical activity in military women students.

Methods

Subjects

Twenty female cadet students of the Military Science University voluntarily participated in this study. The subjects were free of drugs and medication, and had no history of endocrine disorders, diabetes, cardiovascular and respiratory diseases, hypertension, and renal and hepatic problems. The subjects had not used any exogenous anabolic-androgenic steroids, antioxidants or dietary supplements and anti-inflammatories, such as NSAIDs and COX-2 inhibitors, six months before the study. The experimental procedures and study protocols, being fully explained to all the subjects, were approved by the Islamic Azad University's Ethics Committee, Teheran Branch. The subjects had read and understood the details of the experiments before signing a written consent form. The subjects were randomly assigned into two groups of (1) placebo (control), and (2) garlic extract supplement (experimental) along with a physical activity program (n=10 in each group). Since the subjects were living in the dormitory, their diets were controlled. The subjects were asked to decrease their physical activity during supplementation.

Anthropometric measurements

Before the intervention period, all subjects attended the laboratory two days at the baseline. During the familiarisation session, height was measured to the nearest 0.5 cm, without shoes, using a calibrated scale (Cranlea and Company, Bournville, Birmingham, UK). Body mass and total body fat were measured using the X-scan plus II Segmental Body Composition Analyzer (X-scan plus II, Korea), corrected for light indoor clothing. Body mass index (BMI) was calculated as body weight in kilograms divided by height in metres squared (body weight [kg]/height [m]^2). VO_{2max} was measured by the Cooper VO_{2max} Test, estimating how far a subject can run/walk in 12 minutes. Based on the distance covered by the subjects, VO_{2max} was calculated by the following formula: VO_{2max} (ml.kg.min.$^{-1}$) = (Distance covered in metres – 504.9)/44.73[23]. The subjects' characteristics and the data obtained from variables based on the mean and the standard deviation (Mean±SD) are presented in Table 1.

Table 1. Characteristics of the subjects before supplementation and physical exercise. Data are expressed as mean ±SD.

Group	Age(year)	Weight (kg)	Height (cm)	BMI (kg/m2)	VO2max ml.kg.min-1	BF% -
Supplementation	20.0±1.6	55.7±7.1	164.3±4.4	20.7±2.9	47.5±3.5	17.5±2.4
Placebo	20.2±1.5	52.6±5.6	164.4±4.4	19.4±2.1	46.7±4.2	16.8±3.3
p	-	-	-	0.30	0.42	0.65

Parade as physical activity

Fourteen days after garlic extract supplementation, the subjects performed a session of physical activity in the form of military parade. The protocol included five-minute warm-up before a 45-minute parade. The subjects were arranged in four columns in a parade line. Each column included five subjects, who started their 60-minute training with movements such as rotation while stopping, rotation while moving, rotation without weapon, shoulder knot, hand knot, shoulder-arm-and-feet knot while stopping and movement with weapon. Once they left the station, they traversed the front of the station in the lockstep. They then completed their parade exercise with movements, such as bending the head, hands and feet at 45-degree angles so the upper and lower extremities contributed continuously to the exercise protocol. The subjects did not have any extra activity during the parade, and they did not drink any liquid. Care was taken to ensure that the environmental conditions of ambient temperature 22–23°C and relative humidity 50–55% were similar during all tests. For this purpose, the parade was conducted indoors so that temperature and humidity control was provided by a sensor (ThermoPro TP50 Digital).

Garlic extract supplement

The supplement group was given *one* garlic capsule daily—each containing 500 mg of garlic extraction supplement (produced by GOLDARU Company, Iran)—for 14 days. The placebo group received a placebo containing 500 mg of dextrose. The subjects took the capsules with 250 ml water after lunch. The experimental and placebo groups' capsules were identical in appearance (i.e. size, shape and colour). In preparing capsules, 500 mg of garlic extraction supplement (produced by GOLDARU Company, Iran) was provided. The placebo capsules' contents, that is, the garlic extract, were emptied and then filled with dextrose. Therefore, the placebo and supplement capsules were somewhat similar in garlic odour. All capsules (both placebo and garlic capsules) were put in the main garlic container and kept near fresh garlic before being delivered to the subjects. Considering that the odour of the placebo capsules might have been reduced after a while, the packages were delivered every seven days for better monitoring and odour control. Thus, garlic odour was one of the limitations of the study, which may have affected the results. The intake timing was standardised to avoid any possible interference with the results, and the dosage was carefully monitored. Each subject received seven capsules at the end of the seven days. The subjects were asked not to have any citrus, caffeine and phenolic compounds during the protocol. Although all subjects were living in the garrison and took a standard diet, to control the amount of the antioxidants consumed, all subjects were asked to complete a validated food intake questionnaire, recording their food intake every day. Diet was analysed using Food Processor software (Esha Research, Salem, USA) with regard to the antioxidant and caloric content. Subjects were also provided with necessary information concerning the amount to be consumed and how to record it during the intervention period to ensure dietary stability. The results of the dietary analysis are presented in Table 2.

Blood sampling and analysis

Blood samples were gathered in three stages: 1) before any intervention (before supplementation and Cooper test) for baseline analysis as pre-test blood samples; 2) 14 days after garlic extract supplementation; and (3) immediately after a session of parade activity. Pre-test blood samples (5 ml) were obtained from the subjects' antecubital vein in the sitting position before any intervention after a 10-hour fast between 8:00 and 10:00 a.m. Stages 2 and 3 of blood sampling were repeated the same as the pre-test stage by the same technicians.

To measure MDA levels, plasma was separated by centrifugation (1006 gm, 10 min.) immediately after blood sampling at a temperature of 22–23° C and relative humidity of 50–55%. The following procedure measured MDA, according to Yoshioka *et*

Table. 2 Nutrient analysis of the dietary records of the supplement, and placebo groups before and after supplementation and military exercise period. Data are expressed as mean ±SD.

	Time	supplement	placebo	p
Proteins (g)	Pre supplementation	112.5±30.5	109.8±17.2	0.17
	After supplementation	115.0±15.2	118.0±18.2	0.79
	After exercise	120.2±18.2	118.7±16.5	0.44
Carbohydrates (g)	Pre supplementation	399.7±55.0	410.1±23.8	0.06
	After supplementation	402.1±25.1	395.5±21.1	0.07
	After exercise	395.1±25.1	410.5±11.1	0.06
Fat (g)	Pre supplementation	120.1±10.3	115.1±21.2	0.27
	After supplementation	115.2±11.4	113.7±7.2	0.87
	After exercise	109.9±10.5	111.7±7.2	0.11
Kcal	Pre supplementation	3129.7±125.5	3115.0±85.9	0.75
	After supplementation	3105.0±95.5	3113.0±107.5	0.42
	After exercise	3050.0±105.8	3120.0±115.4	0.06
Vitamin C (mg/d)	Pre supplementation	60.0±6.8	57.0±13.2	0.09
	After supplementation	66.5±8.2	58.4±10.6	0.12
	After exercise	59.8±7.3	61.2±5.9	0.33
α- tocopherol (mg/d)	Pre supplementation	4.8±1.1	4.0±0.8	0.77
	After supplementation	5.6±0.9	4.4±1.2	0.49
	After exercise	4.4±0.7	4.9±0.6	0.75
Vitamin A (µg/d)	Pre supplementation	492.3±118	487.0±143.5	0.42
	After supplementation	518.6±132.4	475.5±125.4	0.06
	After exercise	499.4±177.8	488.4±193.7	0.67

Comparison of nutrient data between supplement and placebo was done with independent sample t-test. P<0.05.

al.[24] 0.5 ml of plasma was shaken with 2.5 ml of 20% trichloroacetic acid (TCA) in a 10 ml centrifuge tube. 1 ml of 0.6% 2-thiobarbituric acid (TBA) was added to the mixture, shaken and warmed for 30 min. in a boiling water bath followed by rapid cooling. It was then shaken into a 4 ml nbutyl- alcohol layer in a separation tube. The MDA content in the plasma was determined from the absorbance at 535 nm and 520 nm by a spectrophotometer against butanol. The standards of 5, 10 and_20 nmol/ml tetra ethoxy propane (TEP) were used. The results were expressed as nmol/ml plasma.[24] To measure 8-OHdG, plasma was separated by centrifugation at 2000 rpm for 15 minutes. The leukocytes were separated, and their DNA was extracted under the effect of 0.8. Nuclease P1 and phosphatase acid were located in 1 mmol of EDTA and 10 mmol of sodium acetate (pH=4.5) at 37°C for 30 minutes. Then, it was centrifuged at 1500 rpm for five minutes. The supernatant was filtered and infused into the HPLC column. Also, 5 ng/ml of 8-OHdG standard was infused into the HPLC, and the system recorded the peak standard. The results were expressed as ng/ml.

Statistical analysis

Data were expressed as the mean ± standard deviation. First, the normal distribution of all outcomes was confirmed with the Kolmogorov-Smirnov test. The baseline physical characteristics and nutrient data between supplement and placebo groups were compared using an independent sample student's t-test.

A 2×3 (group×time) ANOVA with repeated measures was used to determine the effects of the garlic extract supplement and placebo on the dependent measures. A Bonferroni's post hoc test was used to identify significant differences when a significant F-ratio was obtained. The statistical significance was set at p≤0.05. All statistical analyses were conducted using the software statistical package SPSS version 19.0.

Results

The dietary intake analysis results showed no significant difference between the placebo and garlic extract supplement groups after supplementation and military physical exercise. There were no differences between the groups at baseline for aerobic power, body weight, body fat percentage, MDA and 8-OHdG (p>0.05).

In addition, there were significant effects of military physical exercise training (p=0.001 and p=0.001, respectively) and interaction of military physical exercise training with supplementation (p=0.001, p=0.001, respectively) on MDA and 8-OHdG levels (Figure 1).

Figure 1 - Changes in the levels of MDA Panel(A) and 8-OHdGPanel(B) before and after supplementation and after military exercise. Data are expressed as Mean ±SD.

Figure 1a

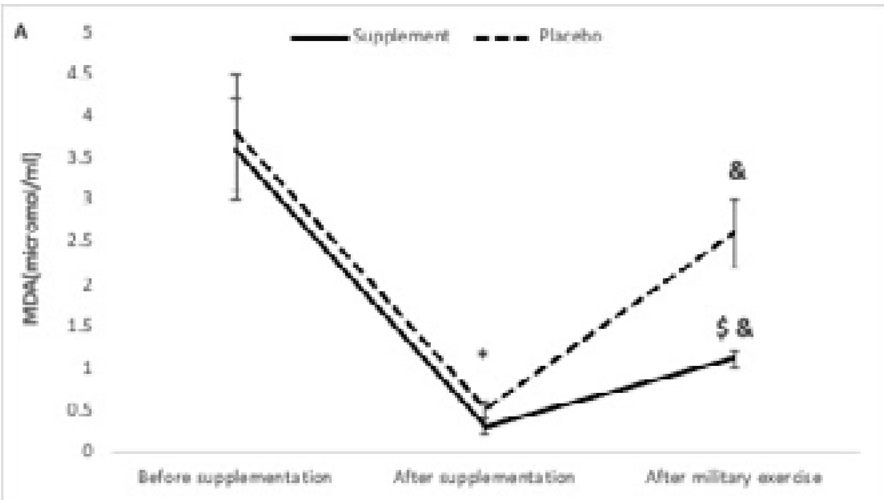
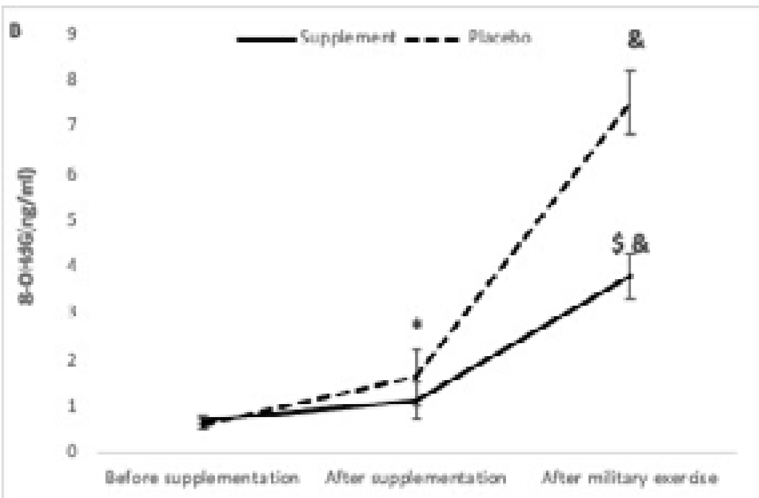


Figure 1b



*Denotes significant decrease compared to before supplementation.

& Denotes significant increase compared to after supplementation.

Ş Denotes significant decrease compared to the placebo group.

The main effect of time (before and after supplementation and after military exercise) on MDA concentration was statistically significant ($F_{2,36}$=321.391, p=0.001, PES=0.947. (The main effect of each group (supplementation, placebo) on MDA concentration was statistically significant ($F_{1,18}$=27.741, p=0.001, PES=0.606). There was a significant interaction between supplement use and time ($F_{2,36}$=17.890, p=0.001, PES=0.498). The concentration of MDA decreased after taking the supplement and placebo, but the concentration increased significantly after the parade. Although the trend of both groups' changes was similar, the concentration of MDA in the garlic supplement group after garlic supplementation and after the parade was significantly lower than the placebo group (Figure 1a).

About 8-OHdG, the main effect of time ($F_{2,36}$=447.847, p=0.001, PES=0.961), group ($F_{1,18}$=97.003, p=0.001, PES=0.843) and time × group interaction ($F_{2,36}$=78.931, p=0.001, PES=0.814) was significant. After supplementation or placebo intake, 8-OHdG level increased significantly in both groups, but only after the parade, AAA concentration was significantly lower in the supplement group than in the placebo group (Figure 1b).

Discussion

This study investigated the effects of garlic extract supplementation on oxidative stress markers following military physical activity. The results showed that garlic supplementation could attenuate MDA and 8-OHdG responses after exercise more than placebo, but it could not prevent oxidative stress after activity.

Before any intervention, BMI and body fat mass of the control and experimental groups were homogenous. Although body composition and fat tissue have a direct relationship with oxidative stress levels,[25] it appears that BMI and body fat mass did not affect the results. On the other hand, the aerobic power levels of the subjects did not have any significant differences. Thus, the effects of physical fitness and oxygen consumption on the ROS process were controlled.

The results showed that 14 days of garlic extract supplementation could not prevent lipid peroxidation induced by military parade. Compared to the placebo group, the increase in MDA level was significantly lower, and in the absence of garlic extract supplementation, the exercise protocol induced lipid peroxidation and DNA damage. This shows that the intensity and time of activity could be a challenge for the antioxidant system. This study found that exercise induces a measurable increase in the oxidative stress biomarkers, which increased MDA concentration three and a half and five times in response to the supplement and placebo group activity. On the other hand, 8-OHdG concentration showed an increase in the supplement and placebo groups. It was reported that had the intensity of the training been higher, the blood's oxidative stress indices would have doubled.[26] Very high-intensity exercise seems to exaggerate this stress response. Contrary to the present study, Saritaş et al. (2011) reported that MDA concentration significantly decreased after healthy trained men completed a 12-minute Cooper test run[27]. The inconsistency in the results of the above-mentioned study and the present study is due to the differences in the intensity of exercise or the training status, the participants' age, BMI and other various indices. It has been reported that all factors, such as the duration and intensity of training, skills, gender, athletic ability and the environmental state, can affect stress-induced oxidative damage.[28] Also, oxygen consumption increases during high-intensity aerobic exercise, and consequently, increases the mitochondrial activity in the constricted muscles.[2] However, some oxygen consumption during metabolism and the mitochondrial respiratory system in the aerobic organisms may convert into superoxide radicals ($O_2^{\bullet-}$), hydrogen peroxide (H_2O_2), hydroxyl radicals (•OH) and singlet oxygen ($^1O_2$), and their production may lead to increased oxidative stress.[29]

The results of this study suggested that garlic extract supplement attenuates levels of MDA oxidative stress and 8-OHdG in comparison with placebo in response to physical activity. The potential mechanism of garlic extract supplementation is that it may reduce the harmful effects of free radicals and oxidative stress related to its antioxidant compounds. This indicates that garlic supplement could enhance the rest level of the antioxidants power or limit the adverse effects of free radicals and ROS production.[30] It has been reported that the use of garlic extract can increase some antioxidant enzymes, such as catalase and glutathione peroxidase.[31] This can explain why garlic extract supplementation reduced oxidative stress production. On the other hand, it has been reported that some of the compounds in garlic, such as allicin, which are dose-dependent, are most effective in clearing free radicals such as hydroxyl radical.[22] It is clear that excess of hydroxyl radical (occurring during exercise) can cause lipid peroxidation, thus damaging cell membranes and lipoproteins.[32] Therefore, it seems that allicin could attenuate lipid peroxidation in the supplement subjects by scavenging hydroxyl radical.

In this study, the garlic extract dose was 500 mg a day. Some reports indicated that garlic extract's effectiveness on the antioxidants indices is sensitive to the dose and the type of antioxidant variable.[33] It was suggested that the SOD enzyme activity increases at a low dose.[34] However, in this study, we did not measure the antioxidant variables and cortisol level to determine the effectiveness of garlic extract and the relevant mechanisms. This is a limitation and disadvantage of the study. It has been reported that both military women and men are exposed to a wide range of stressor events as a part of military training and work assignments that may affect cortisol secretion.[35] Cortisol may increase oxidative damage. On the other hand, it may also initiate up-regulation of antioxidant defences and reduce free radical production. Accordingly, the evaluation of cortisol could further help interpret the results.[36] From the related oxidative stress reduction mechanism, it seems, though, that the consumption dose in the present study was successful enough to improve antioxidant status. Nasiri et al. (2017) reported that garlic can reduce oxidative stress and improve total antioxidant capacity, MDA and total oxidant status (TOS) in diabetic rats.[37]

Lower increase in oxidative stress indices in the supplement group in the present study indicates that garlic supplementation positively affects oxidant/antioxidant balance. The antioxidant compounds in garlic may have prevented oxidative stress caused by exercise and, consequently, decrease oxidative stress and protect the cell structure. In general, the garlic function mechanism and its declining effects on lipid peroxidation may be due to scavenging of free radicals by sulfur compounds like allicin, S-allyl cysteine and sulfur oil.[38] It was reported that garlic and its compounds, including the sulfur factor, help avert lipid peroxidation by inactivating TNF-α and nuclear Factor-Kappa B (NF-kB).[39] Therefore, it seems that allicin's antioxidative mechanism is one of the main features of garlic thiosulfonate that is highly antioxidative, inducing the inhibition of chain-carrying peroxyl radicals and transportation of peroxides. On the other hand, it does not seem that the decrease in lipid peroxidation and 8-OHdG is wholly related to allicin. In this study, these effects may have been the result of the glutathione increment. It has been reported that garlic consumption induces an increase in glutathione, and thus, the body's antioxidant power increases.[39] In general, regardless of garlic compounds, it could be said that garlic supplementation may not exclusively prevent oxidative stress during physical military training. However, as an antioxidant supplement, it could attenuate oxidative stress, accelerate recovery and promote injured tissues' recovery.[40]

Conclusion

In spite of some limitations of the present study, such as not checking the plasma total antioxidant capacity, 14 days of consuming garlic extraction could not prevent oxidative stress following long period exercise in the form of military activity. However, garlic supplementation could attenuate lipid peroxidation and DNA damage markers following physical military training.

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Total and Per-Patient Fiscal Year 2013 VA Disability Compensation and Medical Care Expenditures and Utilization for Vietnam Era Veterans with Service-Connected Disabilities

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Background: While Veterans with 50%+ service connection are entitled to VA disability compensation and prioritised VA care, little is known about disability compensation and medical care expenditures/utilisation among Vietnam Era Veterans with 50%+ service connection.

Methods: We analysed 836 917 Vietnam Era Veterans with service-connected disabilities in 2013. For males (n=828 861) and females (n=8056), we describe total and per-patient FY2013 VA disability compensation and medical care expenditures/utilisation associated with 50%+ service-connection status (0-40% vs 50%+), and Medicare-eligible age status (age <65 vs age 65+).

Results: Overall, those with 50%+ service connection (males = $10 315/28 visits; females = $12 146/36 visits) had higher mean per-patient FY2013 VA medical care expenditures and outpatient utilisation, relative to those rated 0–40% (males = $5520/17 visits; females = $6735/22 visits). By contrast, those who were Medicare-eligible age (males = $9779/27 visits; females = $10 575/32 visits) had lower VA mean per-patient FY2013 medical care expenditures and outpatient utilisation, relative to those below Medicare-eligible age (males = $11 377/31 visits; females = $13 290/39 visits).

Conclusions: For Vietnam Era Veterans with 50%+ service connection, lower per-patient VA medical care expenditures and outpatient utilisation among those of Medicare-eligible age raises the possibility that medical care substitution effects may occur even among those with cost-free VA care. Prospective follow-up studies based on VA/Medicare data are needed to evaluate this possibility.

Introduction

With an annual budget of more than $200 billion in 2019, the US Department of Veterans Affairs (VA) is the largest single healthcare provider in the United States and administers an extensive disability compensation program.[1] Within the VA system, the Veterans Benefits Administration (VBA) administers disability compensation payments while the Veterans Health Administration (VHA) provides medical care.[2] These two programs, disability compensation and medical care, represent long-term budgetary costs borne by the VA.[3]

VBA disability compensation is intended to compensate Veterans for average impairment in earnings resulting from service-connected conditions.[4] ‘Service connected’ refers to conditions that occurred during military service or those that were aggravated by it.[4] VBA disability compensation payments are tied to a ‘combined disability rating’, which expresses accumulated service-connected disability severity on a graduated scale from 0% to 100% in increments of 10% (higher ratings denote greater burden of service-connected disabilities and correspond to higher payments).[5] VBA disability compensation payments in 2013 (year of our study) ranged from $129 to $2816 for Veterans without dependents.[6]

The *Veterans Health Care Eligibility Reform Act* mandates that Veterans with combined degree of service connection 50–100% ('50%+'), as well as those unable to maintain employment due to service-connected conditions (Individual Unemployability [IU]), are entitled to highest-priority, cost-free VHA care for all service and non-service-connected medical conditions, without enrollment.[7-11] In contrast, Veterans with combined degree of service connection 0–40% receive lower priority, cost-free VHA care for their service-connected conditions, but must enroll and may be responsible for co-payments when receiving care for their non-service-connected conditions.[6,7] Surprisingly, while access to VA disability compensation payments and priority no-cost medical care for veterans with 50%+ service connection is mandated by federal law, little is known about VA disability compensation and medical care expenditures and utilisation among Vietnam Era Veterans with service-connected disabilities. We focused on Vietnam Era (1962–1975) Veterans with service-connected conditions because these Veterans tend to have considerable disability compensation and age-related medical care needs,[12-13] and many are dually eligible to receive care from VHA and/or Medicare providers.[14]

The overall objectives of this study were to describe, (1) VA total Fiscal Year 2013 (FY2013) expenditures on VBA disability compensation and VHA medical care for Vietnam Era Veterans with service-connected disabilities; and (2) per-patient costs of each for that same year. Since disability compensation and medical care expenditures vary by degree of service connection,[7-11] gender[15] and age,[16] we examined, (3) VA total and per-patient FY2013 disability compensation and medical care expenditures and (4) medical care (i.e. inpatient and outpatient) utilisation overall, as well as by degree of service connection (0–40% vs 50%+), gender, and age (age <65 vs age 65+). We include medical care utilisation in this study because of its association with medical care cost.[17] In the current study, we hypothesised that there would be large differences in VA total and per-patient FY2013 disability compensation and medical care expenditures and utilisation between Veterans with 50%+ service connection (relative to 0–40% service connection), men (relative to women) and those age 65+ (relative to age <65).

Methods

Research design and study sample

We used a cross-sectional design to identify Vietnam Era Veterans with service-connected disabilities in 2013. Our study population consisted of 1 125 053 Vietnam Era Veterans who had at least one service-connected condition and an active award status recorded in the April 2013 Veterans Service Network Corporate Mini Master File (VETSNET) data extract. Since we were interested in Veterans who were also VHA patients in FY2013, we selected 861 419 (76.5%) with at least one VHA outpatient visit recorded in the VHA Event File (FY2013) or one VHA inpatient visit recorded in the VHA Patient Treatment File (FY2013). We excluded 24 502 (28.4%) Veterans who were not alive in FY2013, or had not served between 1962–1975, or were younger than 59 years of age, or were missing information on age or gender. Our final analytic sample comprised 836 917 Vietnam Era Veterans with service-connected conditions in 2013.

Data sources

We used VETSNET, the primary source of information on Veterans' disability compensation and pension benefits,[18] to create our final analytic sample and ascertain disability compensation payment information from April 2013. We used VHA event files, which contain one record for each outpatient encounter, to ascertain annual VHA outpatient utilisation in FY2013. Outpatient visits were defined using the National Committee for Quality Assurance (NCQA) Healthcare Effectiveness Data and Information Set definition of face-to-face ambulatory visits.[19-20] We used the VHA Patient Treatment Files (PTFs) to ascertain VHA inpatient utilisation in FY2013. The VHA PTFs contain data for inpatient stays at VA medical and domiciliary care centres, contract and community nursing homes, and non-VA hospitals at VA expense, including admission, diagnoses, procedures, surgical episodes, dispositions (discharges) and transfers.[19-20] We used VHA Health Economics Resource Center healthcare cost data files to ascertain inpatient and outpatient ('medical care') expenditures in FY2013. The VHA Health Economics Resource Center files, in estimating average national VHA inpatient and outpatient costs borne by the VA, apply a Medicare payment methodology. Cost estimates for VHA outpatient visits are based on reimbursement rates from Medicare and other healthcare payers to estimate hypothetical payments for outpatient visits; these payments are then adjusted to reflect the actual aggregate cost of VHA outpatient care. In contrast, costs for VHA inpatient stays are calculated using a Medicare cost function estimate derived from characteristics of the patient admission, such as length of stay and diagnosis-related group relative weights.[15]

Study variables

We selected variables based on *a priori* knowledge of factors associated with VA system utilisation and costs.[1] Our primary exposure was 50%+ service-connection status in FY2013. Because Veterans with combined disability ratings of 50%+ receive highest-priority, cost-free VHA medical care, we transformed combined disability rating into a dichotomous (0-40% vs 50%+) 50%+ service-connection status variable. Since IU allows a Veteran to receive VBA disability compensation at the 100% rate, Veterans with IU in this study were considered to have a 100% disability rating and included in the 50%+ service-connected group.

Other variables included age, sex, VBA total and per-patient FY2013 disability compensation payment expenditures, VHA total and per-patient FY2013 medical care expenditures, VHA per-patient FY2013 inpatient and outpatient care utilisation. Because Veterans become eligible for Medicare enrolment at age 65,[21] we transformed age into a dichotomous (age <65 vs age 65+) Medicare-eligible age status variable. Since VETSNET is limited to a single month (i.e. April 2013) of data, we annualised disability compensation payments by multiplying each individual monthly payment by 12. In deriving VBA total and per-patient FY2013 disability compensation expenditures, we aggregated and averaged the annualised FY2013 disability compensation payments. In deriving VHA total and per-patient FY2013 medical care expenditures, we aggregated and averaged estimated annualised FY2013 VHA inpatient and outpatient medical care expenditures. To derive VHA per-patient FY2013 medical care utilisation, we used clinic stop codes to ascertain FY2013 VHA inpatient and outpatient visits (a Veteran could have more than one visit on any given day).

Statistical analysis

The VA New Jersey Health Care System Institutional Review Board approved this cross-sectional study. All analyses were performed with SAS 9.4 (SAS Corp: Cary, NC), were two-tailed and conducted with a 0.05 significance level.

For males and females separately, we stratified VA total and mean and median per-patient FY2013 disability compensation and medical care expenditures by 50%+ service-connection status. We further stratified mean and median per-patient FY2013 disability compensation and medical care expenditures and utilisation, for separate subsets with 0–40% and 50%+ service connection. Totals, means (standard error, s.e.) and medians (interquartile range, i.q.r.) were used to compare FY2013 per-patient disability compensation and medical care expenditures and utilisation. Statistically significant differences were evaluated with chi-square tests for categorical variables, t-tests for normally distributed means, with or without equal variances, Wilcoxon rank-sum and Kruskal Wallace tests for medians. In the results section below, we report means for greater comparability with existing studies.

Results

Overall, almost two-thirds of Vietnam Era Veterans in our sample were 50%+ service connected in 2013. Additionally, the proportion of the sample with 50%+ service connection was similar for males and females and those aged <65 and 65+ (Table 1).

All expenditures are reported in 2013 US dollars. Overall, VA spent an estimated $8.6 billion more (twice as much) in FY2013 on disability compensation ($15.7 billion) than on medical care ($7.1 billion), in this sample. Presumably, because of their greater numbers (males = 828 861, females = 8056), VA spent an estimated $22.3 billion more in FY2013 on disability compensation and medical care for males ($22.5 billion) than for females ($236.9 million), and an estimated $2.8 billion more for those age 65+ ($10.8 billion, n = 552 950) relative to those age <65 ($7.99 billion, n = 283 967). As expected, VA total FY2013 disability compensation and medical care spending for Veterans with 50%+ service connection ($19.7 billion) exceeded expenditures for Veterans with 0–40% service connection ($3.03 billion) by approximately $16.7 billion (Table 1).

As hypothesised, VA mean per-patient FY2013 medical care expenditures and outpatient utilisation were higher for Veterans with 50%+ service connection (males = $10 315/28.7 visits; females = $12 146/36.5 visits), relative to Veterans with 0–40% service connection (males = $5520/16.7 visits; females = $6735/22 visits), in this sample (Table 2).

As further hypothesised for Veterans with 50%+ service connection, VA mean per-patient FY2013 medical care expenditures and outpatient utilisation were lower for those age 65+ (males = $9779/27.5 visits; females = $10 575/31.7 visits), relative to those age <65 (males = $11 377/31.2 visits; females = $13 290/39.9 visits), among the sample (Table 3). Similarly, for Veterans with 0-40%+ service connection, VA mean per-patient FY2013 medical care expenditures and outpatient utilisation were lower for those age 65+ (males = $5122/15.8 visits; females = $6168/20.0 visits), relative to those age <65 (males=$6297/18.6 visits; females = $7179/23.6 visits), among the sample (Table 4).

Table 1. Estimated Fiscal Year 2013 Expenditures for VBA Disability Compensation Payments and VHA Medical Care for service-connected Vietnam Era Veterans Overall and by Gender, Age and Degree of Service-Connection

	Overall	Service-Connection 0-40%	Service-Connection 50%+
Full Sample	**n=836,917**	**n=321,769**	**n=515,148**
Annualized FY2013 disability compensation payments	$15,717,348,174	$1,250,518,902	$14,466,829,272
Estimated FY2013 medical care expenditures	$7,103,552,458	$1,779,866,330	$5,323,686,127
Sum total FY2013 disability compensation payments and medical care expenditures	$22,820,900,632	$3,030,385,232	$19,790,515,399
<65 years	**n=283,967**	**n=109,715**	**n=174,252**
Annualized FY2013 disability compensation payments	$5,314,192,836	$411,772,932	$4,902,419,904
Estimated FY2013 medical care expenditures	$2,680,562,574	$692,305,286	$1,988,257,288
Sum total FY2013 disability compensation payments and medical care expenditures	$7,994,755,410	$1,104,078,218	$6,890,677,192
65+ years	**n=552,950**	**n=212,054**	**n=340,896**
Annualized FY2013 disability compensation payments	$10,403,166,338	$838,745,970	$9,564,409,368
Estimated FY2013 medical care expenditures	$4,422,989,884	$1,087,561,044	$3,335,428,840
Sum total FY2013 disability compensation payments and medical care expenditures	$10,845,415,622	$1,926,307,014	$12,899,838,208
Males	**n=828,861**	**n=318,905**	**n=509,956**
Annualized FY2013 disability compensation payments	$15,562,784,382	$1,239,588,054	$14,323,196,328
Estimated FY2013 medical care expenditures	$7,021,199,035	$1,760,575,476	$5,260,623,559
Sum total FY2013 disability compensation payments and medical care expenditures	$22,583,983,417	$3,000,163,530	$19,583,819,887
Females	**n=8,056**	**n=2,864**	**n=5,192**
Annualized FY2013 disability compensation payments	$154,563,792	$10,930,848	$143,632,944
Estimated FY2013 medical care expenditures	$82,353,422	$19,290,854	$63,062,568
Sum total FY2013 disability compensation payments and medical care expenditures	$236,917,214	$30,221,702	$206,695,512

Notes: 2013 US $; Abbreviations: VHA=Veterans Health Administration, VBA=Veterans Benefits Administration, IQR=Interquartile Range.

Table 2. Estimated Fiscal Year 2013 Per-Patient VBA Disability Compensation Payments and VHA Medical Care Expenditures and Utilization for service-connected Vietnam Era Veterans by Gender and Degree of Service-Connection

	0-40%	50%+	p[1]	0-40%	50%+	p[2]
N (%)	318,905 (38.4%)	509,956 (61.5%)		2,864 (35.5%)	5,192 (64.4%)	
Annualized FY2013 per-patient disability compensation payments						
Mean (s.e.)	$3,887.01 (2,319) n=318,905	$28,087.12 (11,517) n=509,956	<.0001	$3,816.64 (2,207) n=2,864	$27,664.28 (12,045) n=5,192	<.0001
Median (i.q.r.)	$3,060 (1,548-5,304)	$33,792 (16,824-35,676)	<.0001	$3,060 (1,424-6,301)	$33,792.00 (15,516-35,052)	<.0001
Estimated FY2013 per-patient medical care expenditures						
Mean (s.e.)	$5,520.69 (10,573) n=318,905	$10,315.84 (15,013) n=509,956	<.0001	$6,735.63 (11,158) n=2,864	$12,146.10 (15,841) n=5,192	<.0001
Median (i.q.r.)	$2,443.73 (1,122-5,314)	$5,479.38 (2,581-11,150)	<.0001	$3,134.07 (1,336-7,271)	$6,829.19 (3,057-14,398)	<.0001
Estimated FY2013 per-patient outpatient medical care expenditures						
Mean (s.e.)	$3,670.03 (5,644) n=316,153	$6,431.32 (8,050) n=506,511	<.0001	$4,538.56 (6,342) n=2,849	$7,426.96 (8,401) n=5,146	<.0001
Median (i.q.r.)	$1,964.09 (916-4,246)	$4,055.01 (1,855-8,057)	<.0001	$2,469.88 (1,047-5,530)	$4,889.65 (2,116-9,678)	<.0001
FY2013 per-patient outpatient medical care visits						
Mean (s.e.)	16.7 (20.7) n=316,153	28.7 (30.3) n=506,511	<.0001	22.0 (25.7) n=2,864	36.5 (39.8) n=5,192	<.0001
Median (i.q.r.)	10.0 (5.0-21.0)	20.0 (10.0-38.0)	<.0001	14.0 (5.0-29.0)	25.0 (12.0-49.0)	<.0001
Estimated FY2013 per-patient inpatient medical care expenditures						
Mean (s.e.)	$19,243.82 (19,181) n=17,296	$20,041.80 (19,961) n=52,469	<.0001	$17,102.63 (16,317) n=193	$19,265.18 (1,910) n=656	<.0001
Median (i.q.r.)	$12,209 (5,640-26,315)	$12,710 (5,758-27,668)	<.0001	$11,386.00 (5,560-25,481)	$12,275.00 (5,941-25,369)	<.0001
FY2013 per-patient inpatient medical care visits						
Mean (s.e.)	1.47 (0.90) n=17,296	1.60 (1.08) n=52,469	<.0001	1.45 (0.76) n=193	1.59 (1.03) n=656	0.0303
Median (i.q.r.)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	<.0001	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.3250
	MALES (828,861)			FEMALES (8,056)		

Notes: p[1]=among male subset, differences between those with 50%+ vs. 0-40%; p[2]=among female subset, differences between those with 50%+ vs. 0-40%; Dollars rounded to nearest whole dollar. Abbreviations: VHA=Veterans Health Administration, SE=standard error, VBA=Veterans Benefits Administration, PTSD=Post-traumatic stress disorder, IQR=Interquartile Range, n=sample size. Statistically significant differences ($p<0.05$) were assessed using t-tests (for continuous variables), and Wilcoxon rank sum tests (for non-normal, continuous variables).

Table 3. Estimated Fiscal Year 2013 Per-Patient VBA Disability Compensation Payments and VHA Medical Care Expenditures and Utilization for Vietnam Era Veterans with 50%+ Service-Connection, by Gender and Age

	Age <65	Age 65+	p^1	Age <65	Age 65+	p^2
N (%)	171,248 (33.5%)	338,708 (66.4%)	--	3,004 (57.8%)	2,188 (42.1%)	--
Annualized FY2013 per-patient disability compensation payments						
Mean (s.e.)	$28,137.05 (11,344) n=171,248	$28,061.88 (11,603) n= 338,708	0.0277	$27,964.83 (11,741) n=3,004	$27,251.64 (12,441) n=2,188	0.0351
Median (i.q.r.)	$33,792 (16,824-35,676)	$33,792 (16,716-35,676)	<.0001	$33,792 (15,516-35,070)	$33,792 (14,640-34,992)	0.1146
Estimated FY2013 per-patient medical care expenditures						
Mean (s.e.)	$11,377.26 (1,587) n=171,248	$9,779.19 (14,527) n=338,708	<.0001	$13,290.23 (16,546) n=3,004	$10,575.29 (14,678) n=2,188	<.0001
Median (i.q.r.)	$33,792 (16,824-35,676)	$5,151.34 (2,398-10,549)	<.0001	$7,653.44 (3,658-15,998)	$5,582.01 (2,426-12,010)	<.0001
Estimated FY2013 per-patient outpatient medical care expenditures						
Mean (s.e.)	$6,962.12 (8,403) n=170,115	$6,162.89 (7,852) n=336,396	<.0001	$8,194.94 (8,977) n=2,981	$6,369.52 (7,408) n=2,165	<.0001
Median (i.q.r.)	$4,520.37 (2,133-8,696)	$3,828.59 (3,722-17,332)	<.0001	$5,495.59 (2,569-10,546)	$3,998.18 (1,695-8,315)	<.0001
FY2013 per-patient outpatient medical care visits						
Mean (s.e.)	31.2 (32.5) n=170,115	27.58 (28.9) n=36396	<.0001	39.9 (43.7) n=2,981	31.7 (33.0) n=2,165	<.0001
Median (i.q.r.)	22.0 (11.0-41.0)	19.0 (9.0-36.0)	<.0001	28.0 (14.0-52.0)	21.0 (10.0-42.0)	<.0001
Estimated FY2013 per-patient inpatient medical care expenditures						
Mean (s.e.)	$20,346.50 (19,958) n=20,247	$19,850.34 (19,961) n=32,222	0.0056	$19,213.07 (19,837) n=408	$19,350.91 (19,806) n=248	0.9312
Median (i.q.r.)	$13,040 (6,087-28,0652)	$12,572.50 (5,535-27,371)	<.0001	$12,064.50 (6,155-24,789)	$13,136 (5,361-26,454)	0.9615
FY2013 per-patient inpatient medical care visits						
Mean (s.e.)	64.5 (46.9) n=20,247	62.2 (41.7) n=32,222	0.2147	76.1 (59.7) n=408	68.7 (51.1) n=248	0.2972
Median (i.q.r.)	53.0 (34.0-80.0)	53.0 (34.0-81.0)	0.6048	63.5 (41.0-96.0)	58.0 (35.0-89.0)	0.1086
	MALES (N=509,956)			FEMALES (N=5,192)		

32,222

Notes: p^1=among male subset, differences between those with 50%+ vs. 0-40%; p^2=among female subset, differences between those with 50%+ vs. 0-40%; Dollars rounded to nearest whole dollar. Abbreviations: VHA=Veterans Health Administration, SE=standard error, VBA=Veterans Benefits Administration, PTSD=Post-traumatic stress disorder, IQR=Interquartile Range, n=sample size. Statistically significant differences ($p<0.05$) were assessed using t-tests (for continuous variables), and Wilcoxon rank sum tests (for non-normal, continuous variables).

Table 4. Estimated Fiscal Year 2013 Per-Patient VBA Disability Compensation Payments and VHA Medical Care Expenditures and Utilization for Vietnam Era Veterans with 0-40% Service-Connection, by Gender and Age

	Age <65	Age 65+	p^1	Age <65	Age 65+	p^2
N (%)	108,109 (33.9%)	210,796 (66.1%)	--	1,606 (56.1%)	1,258 (43.9%)	--
Annualized FY2013 per-patient disability compensation payments						
Mean (s.e.)	$3,752.22 (2,279) n=108,109	$3,956.15 (2,336) n=210,796	<.0001	$3,813.55 (2,251) n=1,606	$3,820.58 (2,150) n=1,258	0.9322
Median (i.q.r.)	$3,060 (1,548-5,305)	$3,060 (1,548-5,304)	<.0001	$3,060 (1,548-5,304)	$3,060 (1,548-5,304)	0.6474
Estimated FY2013 per-patient medical care expenditures						
Mean (s.e.)	$6,297.12 (11,579) n=108,109	$5,122.49 (9,994) n=210,796	<.0001	$7,179.59 (11,750) n=1,606	$ 6,168.86 (10,330) n=1,258	0.0145
Median (i.q.r.)	$2,780.14 (1,261-6,120)	$2,286.88 (1,059-4,920)	<.0001	$3,343.36 (1,395-7,970)	$ 2,768.39 (1,285-6,455)	0.0018
Estimated FY2013 per-patient outpatient medical care expenditures						
Mean (s.e.)	$4,069.78 (6,012) n=107,132	$3,465.15 (5,435) n=209,021	<.0001	$4,889.48 (6,651) n=1,593	$4,093.50 (5,900) n=1,256	0.0009
Median (i.q.r.)	$2,229.47 (1,021-4,819)	$1,844.36 (872-3,962)	<.0001	$2,695.88 (1,125-6,098)	$2,186.32 (981-4,850)	<.0001
FY2013 per-patient outpatient medical care visits						
Mean (s.e.)	18.6 (22.9) n=108,109	15.8 (19.4) n=209,021	<.0001	23.6 (28.0) n=1,593	20.0 (22.2) n=1,256	0.0002
Median (i.q.r.)	11.0 (5.0-23.0)	9.0 (4.0-20.0)	<.0001	15.0 (6.0-30.0)	12.0 (6.0-26.0)	0.0005
Estimated FY2013 per-patient inpatient medical care expenditures						
Mean (s.e.)	$19,931.51 (19,511) n=6,989	$18,777.51 (18,941) n=10,307	0.0001	$17,102.88 (16,693) n=109	$17,102.31 (15,916) n=84	0.9998
Median (i.q.r.)	$12,749 (5,907-26,942)	$11,810 (5,449-25,706)	0.0001	$10,399 (6,013-24,966)	$12,757 (5,393-26,370)	0.8425
FY2013 per-patient inpatient medical care visits						
Mean (s.e.)	53.4 (40.6) n=6,989	50.9 (35.1) n=10,307	0.2315	66.6 (54.3) n=109	55.0 (32.0) n=84	0.9796
Median (i.q.r.)	42.0 (28.0-66.0)	43.0 (28.0-64.0)	0.1007	54.0 (34.0-77.0)	52.0 (28.0-74.5)	0.6277
	MALES (N=318,905)			FEMALES (N=2,864)		

Notes: p^1=among male subset, differences between those with 50%+ vs. 0-40%; p^2=among female subset, differences between those with 50%+ vs. 0-40%; Dollars rounded to nearest whole dollar. Abbreviations: VHA=Veterans Health Administration, SE=standard error, VBA=Veterans Benefits Administration, PTSD=Post-traumatic stress disorder, IQR=Interquartile Range, n=sample size. Statistically significant differences ($p<0.05$) were assessed using t-tests (for continuous variables), and Wilcoxon rank sum tests (for non-normal, continuous variables).

Discussion

In this study of Vietnam Era Veterans with VA service-connected disabilities, total FY2013 expenditures for VA disability compensation and medical care exceeded $22 billion: $15.7 billion was spent on disability compensation payments and $7.1 billion on medical care. In FY2013, about one-fifth of total VA expenditures that year ($142.8 billion, according to VA)[22] went to disability compensation payments and medical care for our sample of Vietnam Era Veterans with service-connected disabilities. There were some important differences among subgroups. Among men and women in our sample, being 50%+ service connected was associated with higher per-patient VA disability compensation and medical care expenditures and outpatient utilisation. In contrast, being Medicare-eligible age (65+) was associated with lower per-patient VA medical care expenditures and utilisation, but similar per-patient VA disability compensation, in FY2013.

US Veterans represent a population who have served their country, many facing risks to both short- and long-term health during their active-duty military service. Because many Veterans have served on hazardous missions, including combat, Veterans with service-connected disabilities are a clinically complex population.[6-10] In recognition, the US Congress has mandated that Veterans with the highest burden of service-connected disabilities (i.e. 50%+) are entitled to large disability compensation payments and highest-priority, cost-free VHA care for all medical conditions.[6-9] Consistent with Congressional intent to reduce barriers to service-connection benefits for Vietnam Era Veterans—Congress and VA presume service connection for Vietnam Theatre Veterans with specific diagnosed medical conditions—we observed that almost two-thirds of the overall sample of Vietnam Era Veterans with service-connected disabilities were 50%+ service connected in FY2013. By comparison, only about one-third of Vietnam Era Veterans with service-connected disabilities were 50%+ service connected in FY2001, according to VA.[23] Relative to FY2001, the higher proportion in our overall sample with 50%+ service connection is consistent with government reporting that since the late 1990s, overall total and per-patient spending on VA disability compensation and medical care has grown faster than inflation, despite an overall decline in the number of living Veterans.[24-25]

Since Veterans with 50%+ service connection, including those with IU, are eligible for large VBA disability compensation payments and highest-priority, cost-free VHA care,[6] we hypothesised that Vietnam Era Veterans with 50%+ service connection (relative to 0–40%) would have higher medical care expenditures and utilisation in FY2013. Consistent with expectations, we observed large differences in FY2013 per-patient VA medical care spending and outpatient utilisation for those with 50%+ service connection, relative to those with 0–40%. Notably, both men and women in our sample made a substantial number of outpatient visits, in FY2013. For instance, the mean number of outpatient visits in FY2013 for male and female veterans with 50%+ service connection was 28 and 36 visits, respectively. By comparison, similarly aged adults in the US general population during the same period averaged between 6–12 outpatient visits, according to the Agency for Healthcare Research and Quality.[26]

As many older VHA patients are dual enrollees of VHA/Medicare, and most dual enrollees utilise some private sector healthcare services covered by Medicare,[15,23,27,28] we anticipated large differences in medical care expenditures and utilisation between those aged 65+ relative to those aged <65. Consistent with expectations, for males and females, we found that Veterans who were age 65+ had lower FY2013 per-patient VA medical care expenditures and used less VHA outpatient care than those aged <65. Our finding that among Veterans with 50%+ service connection, VA spent less in FY2013 on medical care for those who were Medicare-eligible age is consistent with prior studies, which have reported considerable dual-system use among older VHA patients in general.[29-31] In this context, we suspect but cannot confirm that even Veterans eligible for Congressionally-mandated highest-priority, cost-free care may use non-VA providers, at least for some medical care services. Subsequent studies using VA and Medicare data are needed to evaluate the dual-system utilisation patterns of Vietnam Era Veterans with 50%+ service connection.

Historically, female Veterans, in general, have been less likely than their male counterparts to enroll in or use VA benefits.[15] While studies have compared VA service-connection award approval rates between male and female Vietnam Veterans,[32-33] differences in VA disability compensation and medical care expenditures and utilisation between male and female Vietnam Era Veterans with service-connected disabilities have received little attention. However, the number of women with service-connected disabilities has been increasing since the 1970s.[32] Among our sample, two findings are noteworthy. First, similar proportions of male and female Vietnam Era Veterans in our FY2013 sample were 50%+ service connected. This finding, which requires replication, suggests that policies and programs intended to reduce barriers to 50%+ service connection may be benefiting males and females equally. This is encouraging if true, given female Veterans' historical tendency to use fewer VA benefits than males. Second, among female Vietnam Era Veterans with 50%+ service connection, similar to their male counterparts, those who were Medicare-eligible age had lower per-patient medical care costs and outpatient utilisation, relative to those below Medicare-eligible age. This is consistent with our contention that Veterans, irrespective of gender, who are eligible for Congressionally-mandated highest-priority cost-free care may prefer to use non-VA providers when barriers are reduced due to age-related Medicare eligibility.

While VHA healthcare benefits are arguably the more visible benefit of service connection, our results illustrate that among our 2013 sample, the preponderance of VA spending went for disability compensation payments to Vietnam Era Veterans. Our finding that FY2013 per-patient spending was approximately two times higher for disability compensation than for medical care is consistent with recently expressed concerns about VA disability benefits long-term affordability.[6,8,13,24] VA disability compensation spending, as a proportion of total annual VA spending, has increased dramatically between FY2001–2013, for all periods of service. In FY2001, VA disability compensation ($15.8 billion) and medical care ($23.1 billion) spending represented approximately 29% and 42% of total FY2001 expenditures ($54.5 billion), respectively.[22,23] By comparison, little more than a decade later, VA disability compensation ($54.9 billion) and medical care ($55.9 billion) spending in FY2013 represented approximately 38% and 39% of total FY2013 expenditures ($142.8 billion), respectively.[34,35]

Historically, the bill for Veterans' disability compensation costs has come due many decades after a conflict. The peak year for paying disability compensation to American Veterans was 1969 for World War I Veterans and the mid-1980s for World War II Veterans.[36] Concerning Vietnam Era Veterans, disability compensation payments may have not yet peaked.[31] Congress has recently expanded service-connection benefits eligibility to more than 20 000 'Blue Water Navy' Veterans, who served aboard ships that operated off the coast of the Republic of Vietnam during the Vietnam War.[33] The magnitude of future per capita expenditures may be even higher for Gulf War Era Veterans, characterised by higher survival rates, more generous VA benefits, earlier granting of service-connection benefits, and newer and more expensive medical treatments.[6,13,24] Currently, the US continues to expand Veteran disability compensation programs, making it easier for Veterans to receive service-connected disability compensation for conditions attributed to military-related exposures, which are difficult to confirm in retrospect (e.g. Agent Orange).[32,33,36,37] Consequently, the percentage of service members who have accessed VBA disability benefits and medical care has risen to unprecedented levels,[6,13,19,24] raising cost concerns. This underscores the importance of forecasting studies, which can predict the long-term costs of VBA disability compensation and VHA healthcare for Veterans with and without service-connected conditions.

Government reporting suggests that disability compensation spending for Vietnam Era Veterans with service-connected conditions may continue to increase at a rate greater than inflation. In that case, VBA disability compensation expenditures will likely grow disproportionately to VHA medical care expenditures over the lifetimes of currently living Veterans and active-duty military personnel. Government reports also predict an increasing reliance on private insurance or Medicare, although the recent expansion of VA-reimbursed care in the community may change that trajectory. Future studies might wish to consider our findings in the context of the recently-enacted 'VA Maintaining Systems and Strengthening Integrated Outside Networks Act' (the VA MISSION Act), which will presumably further influence Veterans' decision-making about healthcare and related costs.

Several limitations should be considered in the context of this analysis. First, the cross-sectional design precludes establishing temporality between spending and service-connection status. Second, in identifying Vietnam Era Veterans, there is some possibility of misclassification. Third, because VETSNET is a snapshot of Veterans receiving disability compensation for service-connected conditions in a single month (i.e. April 2013), we annualise FY2013 expenditures from a single month's data. Fourth, because we did not have access to Medicare claims data for this analysis, we assumed that Veterans who were aged 65+ were eligible for Medicare.[15,18,21] However, since younger Veterans with Social Security Disability Insurance for two or more years may also be eligible for Medicare, observed differences in medical care costs/utilisation for those of Medicare-enrollment age (relative to those below Medicare-enrollment age) may be underestimated. Finally, because we did not have access to pharmacy data, pharmacy expenditures and utilisation were not included in this analysis. This study also has important strengths. Most notably, this is the first study to use a large sample of Vietnam Era Veterans with service-connected disabilities to evaluate total and per-patient FY2013 VA disability compensation and medical care costs associated with gender, 50%+ service connection and Medicare-eligible age in FY2013.

Conclusion

VBA disability compensation payments for Vietnam Era Veterans appear costlier to the VA than VHA medical care benefits, even for Veterans eligible for highest-priority, cost-free care. Current policy generally supports consistent and continued payment of VBA disability compensation for the life of a Veteran, while VHA medical care expenditures may fluctuate based on factors such as gender or age. These findings should prompt ongoing policy discussions about potential budgetary impacts of expanding the pool of individuals eligible for VA service connection. To help policymakers assess the budgetary risks associated with reducing barriers to 50%+ service-connection benefits, future studies that forecast VA disability compensation and medical care costs 10–20 years in the future would provide invaluable insights into potential impacts of any policy changes.

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HMAS Sydney II and HMAS Sydney IV – Comparative Dental Health

R Lain, M Page

Abstract

Background: Dental records of HMAS *Sydney* II (lost in 1941) were examined during previous research on the Unknown Sailor's possible identity. The poor state of oral health was noted. Comparison with a modern-day cohort of crew from *Sydney* IV was considered a potentially useful analysis noting military population dental data from the late 1930s is relatively rare.

Purpose: To quantify the difference in oral health between RAN members in the 1930s and the early 2000s.

Materials and Methods: 256 records on entry to the RAN from *Sydney* II were compared to 114 records from *Sydney* IV. Age on entry was recorded. Parameters used were the DMFT score (number of Decayed, Missing or Filled Teeth) and T-health score (a composite score based on DMFT score indicating quality of dental function).

Results: Mean age on entry was 19.5 years (median 18 years) for *Sydney* II and 21.5 years (median 19 years) for *Sydney* IV. For Sydney II, 20 of 256 (7.8%) members had a DMFT score of 0 (no Decayed, Missing or Filled Teeth); for *Sydney* IV 22 of 114 (19%) had a DMFT score of 0. For Sydney II, 10% of the crew had a DMFT of 16 or more; in *Sydney* IV only one member had a DMFT of 16 or more. The mean T-health score for *Sydney* II was 25.5; and 27.8 for *Sydney* IV.

Conclusion: Historical data has significant limitations for analysis. However, DMFT and T-health scores give a broad indication of oral health. This study supports and quantifies the anticipated improvement in oral health in the RAN from the late 1930s to today.

Introduction

On 19 November 1941, HMAS *Sydney* II, a modified Leander class light cruiser of 6700 tons, was lost following a battle with the disguised German raider HSK *Kormoran* off Carnarvon, Western Australia. There were no survivors among the 645 crew. Three months later a Carley float was detected off Christmas Island and retrieved. The float contained a decomposing body. The remains were buried on Christmas Island; however, partly due to the island's occupation a few weeks later by the Japanese, the location of the grave was lost. A RAN-led team located the grave in 2006 and recovered the remains of what had become known as the Unknown Sailor. Since then, there has been ongoing activity to identify the remains, utilising the three stand-alone identification modes recognised by Interpol: odontology, fingerprint techniques and biology (DNA techniques). These are informed and supported—particularly in this case of historical remains—by physical anthropology techniques and property analysis (uniform, equipment, grave contents). At the time of publication of this article, the Unknown Sailor—the only remains ever recovered from HMAS *Sydney* II—remains unidentified.

While the original 645 dental records of those members of HMAS *Sydney* went down with the ship in 1941, 256 members of *Sydney's* crew had surviving supplemental dental records, collected at their time of entry to the RAN. These were archived at the Sea Power Centre in Canberra. Facsimiles of these records were made available for a second pass analysis in the hopes of leading to the potential identification of the Unknown Sailor. During this process, it was noted that the records reflected a relatively poor standard of oral health. RAN members' oral health in the early 1900s, while long assumed to be poorer than that of the modern population, has never been formally compared to oral health in the current RAN. It was thought that it may be useful to analyse these records, which represent some of the earliest military dental data available, in order to support some of the assumptions made about dental health in the 1930s. The records from *Sydney* II were compared with those of the recently decommissioned HMAS *Sydney* IV, an Adelaide class guided missile frigate of 4100 tons, to gain a quantitative and qualitative assessment of the observed difference in oral health status of serving members in the mid-1930s to those of present day.

Materials and methods

Facsimiles of the 256 available on-entry dental records from HMAS *Sydney* II were collated. The number of decayed, missing and filled teeth (DMFT score) was noted for each record, in addition to age at the time of entry. T-health scores were also calculated as a measure of comparative health and dental function (see Discussion for explanation of DMFT and T-health score).

Ethical approval for a review of the HMAS *Sydney* IV records was obtained from the Australian Defence Health Research Ethics Committee. The dental health at the time of entry for each member was recorded for this population using the DMFT index. Features such as the presence of dentures were also noted. Fissure sealants, a modern preventative treatment modality that seals deeply fissured occlusal (biting) surfaces of teeth that are susceptible to decay through the application of a restoration, commonly a composite resin (often without the need to remove any tooth structure) were not recorded as restorations for this study. Data from the two populations were then analysed to obtain quantitative measures of oral health for both populations to allow valid comparison.

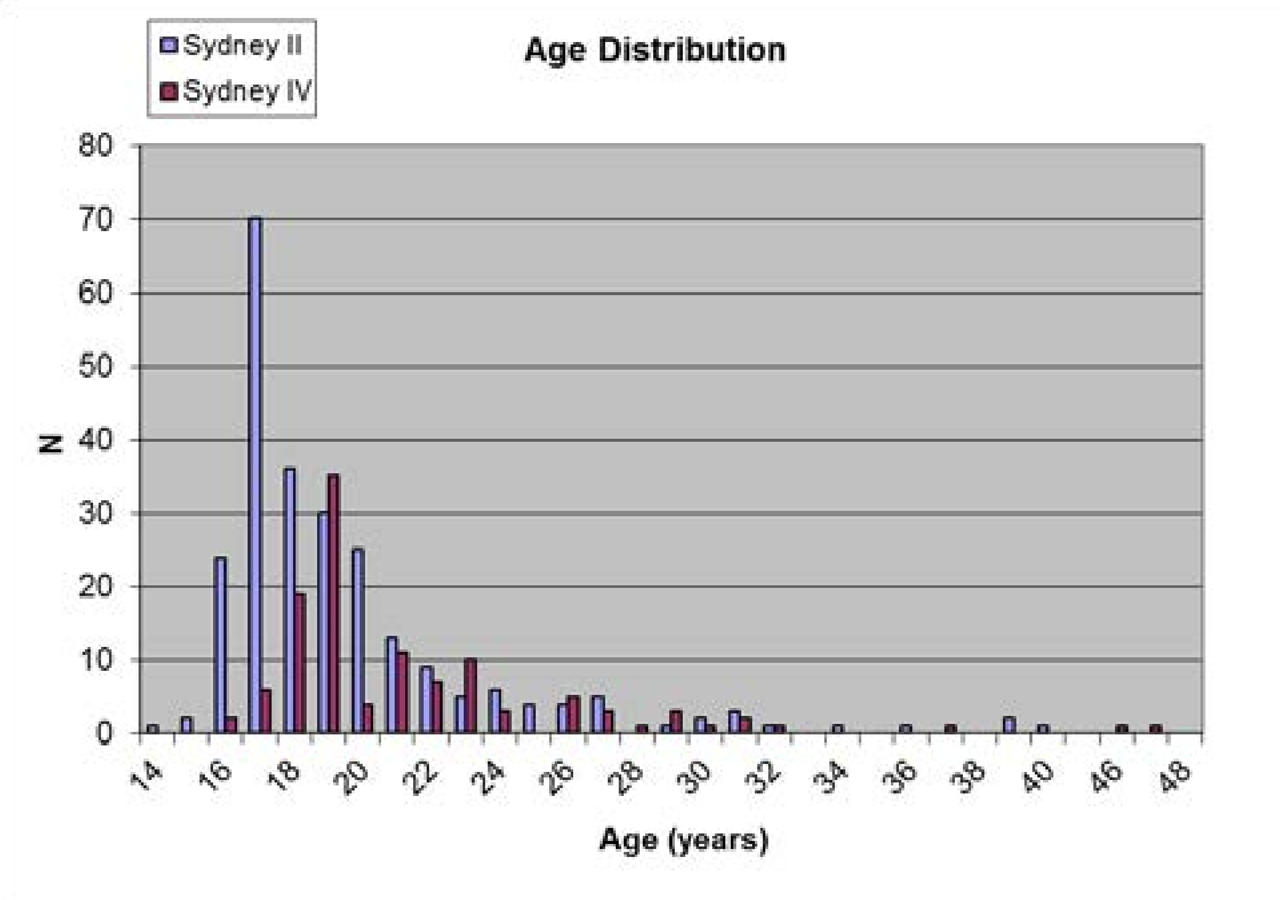
Results

Population data obtained from the 256 HMAS *Sydney* II on-entry records are summarised in Table 1. Mean joining age was 19.5 years (median 18 years). The overwhelming majority of members were rated sailors, with only two surviving officer records. Only 20 out of 256 members (7.8%) with dental records had no decayed, missing or filled teeth charted (DMFT = 0). Just over a third (36%) had a DMFT of less than four, and approximately 10% had a DMFT of 16 or more. Three of the members were completely edentulous (DMFT = 32), with the least partially dentate member having only four teeth remaining. Very few of the partially dentate members had a denture recorded in the dental record on enlistment. Thirty-two members wore a denture. Of the 256 members, 243 had no restorative work (fillings) charted on entry,

Table 1 - Summary Data

	HMAS ***Sydney* II** (n=114)				**HMAS** ***Sydney* IV** (n=256)			
SCORE	DMFT	D	M	F	DMFT	D	M	F
< 4	92	212	126	247	52	101	97	84
4 to 7	69	33	75	4	39	10	13	23
8 to 11	48	6	25	2	16	3	4	5
12 to 15	23	-	10	-	4	-	-	1
16 to 19	13	1	8	-	3	-	-	1
20 to 23	3	-	3	-	-	-	-	-
24 to 27	2	-	1	-	-	-	-	-
28 +	4	-	4	-	-	-	-	-
	HMAS ***Sydney* II**				**HMAS** ***Sydney* IV**			
SCORE	DMFT	D	M	F	DMFT	D	M	F
< 4	36%	84%	50%	98%	46%	89%	85%	74%
4 to 7	27%	13%	30%	2%	34%	9%	11%	20%
8 to 11	19%	2%	10%	1%	14%	3%	4%	4%
12 to 15	9%	-	4%	-	4%	-	-	1%
16 to 19	5%	-	3%	-	3%	-	-	1%
20 to 23	1%	-	1%	-	-	-	-	-
24 to 27	1%	-	-	-	-	-	-	-
28 +	2%	-	2%	-	-	-	-	-
	HMAS ***Sydney* II**				**HMAS** ***Sydney* IV**			
	DMFT	D	M	F	DMFT	D	M	F
Mean	6.7	1.5	5.1	0.1	4.8	1.2	1.1	2.4
Mode	3.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Median	5.0	1.0	3.0	0.0	4.0	0.0	0.0	1.5

Figure 1 – Age distribution of samples



with decayed and missing teeth accounting for the majority of the DMFT scores. Two hundred and eighteen members had one or more missing teeth on entry, and 134 had one or more decayed teeth.

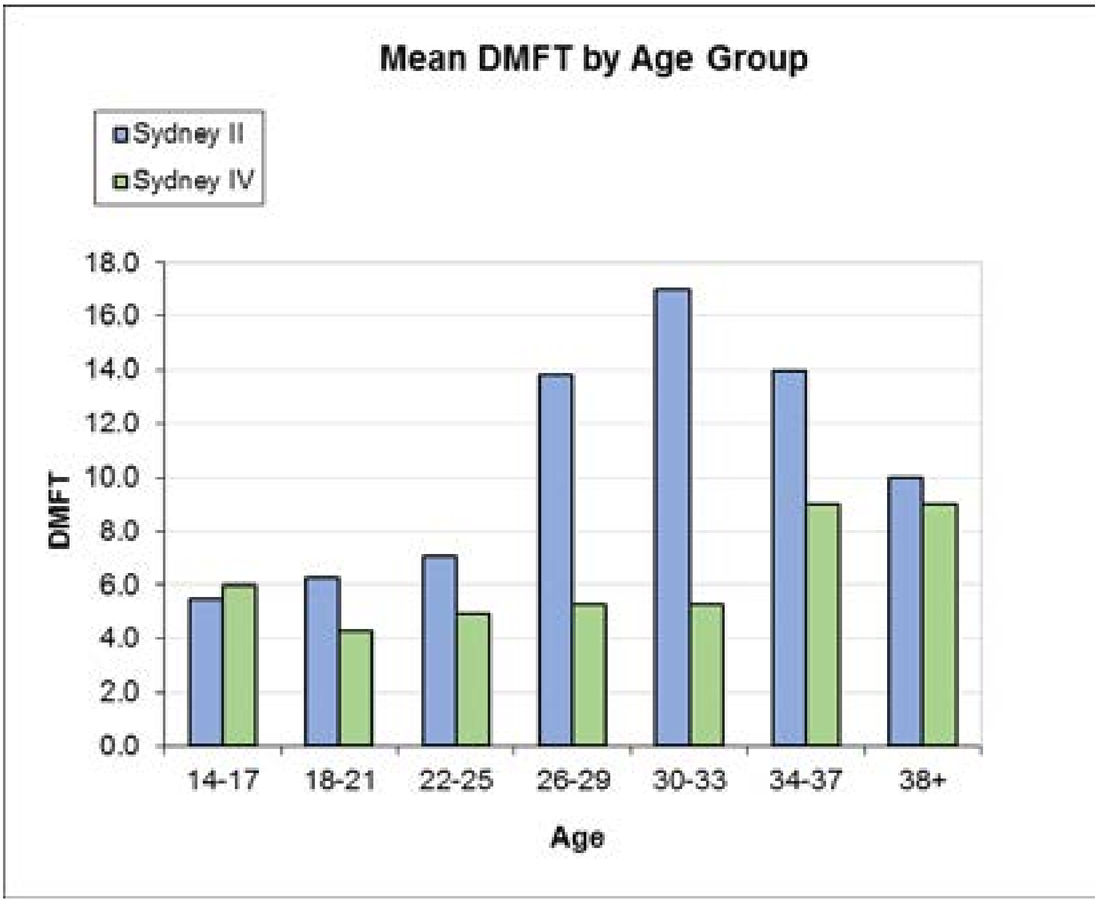
One hundred and fourteen documents were obtained from HMAS *Sydney* IV, representing 100% of posted strength at the time of the study. Population data are likewise summarised in Table 1. The age distribution was similar to that of *Sydney* II, with a skew towards younger members (Figure 1). Mean age at enlistment was 21.5 years (median 19 years). From a total of 114 members, 22 had a DMFT score of 0 on entry (19%). The maximum DMFT was 18, represented by 18 filled teeth in a member born in the 1960s who joined as a 19-year-old. The highest number of missing teeth in any one member was nine. Fifty-six members had one or more decayed teeth, 78 members had one or more filled teeth, and 46 members had one or more missing teeth.

While the mean DMFT scores on entry differed between *Sydney* II and IV populations by a relatively small degree (6.7 vs 4.8, $p < 0.001$), the relative progression of DMFT scores differed markedly between the two populations according to age, as can be seen in Figure 2. The mean DMFT for those in the 26+ age group was 14.1 for the *Sydney* II population (n=21) and 5.8 for the *Sydney* IV population (n=19). T-health scores unsurprisingly indicate that the *Sydney* II population had overall poorer dental health as a cohort compared to the modern population in *Sydney* IV. The mean T-health score in the *Sydney* II population was 25.5, compared to 27.8 for the *Sydney* IV group.

Discussion

The data presented here confirm other studies on historical military populations. The overall dental health of recruits was significantly poorer during the mid-20th century compared to that of today.[1,2,3] For members in the early to mid-1900s, the vast majority of early dental treatment did not involve restorative treatment. Data collected from the entry examinations of 350 17-year-olds between 1928 and 1933 showed that 88% of the first molars were affected by caries, 68% being already extracted or

Figure 2 – Age-distributed DMFT Scores



classified as 'irreparable' requiring extraction. A further study by the same author of 1750 18-year-olds on entry between 1937 and 1938 found 52% of first molars classified as 'irreparable'.[4] Only 10 members (<4%) of the HMAS *Sydney* II crew had received a restoration by the time they entered service. This can be compared to *Sydney* IV's crew, where 78 (70%) of members on entry had received a restoration of some sort. This is reflective of the shift in community attitude towards dental health in the last 80 years, in combination with the advent of government-sponsored public dental programs such as school dental services, programs targeted at oral health in children and later fluoridation of the water supply in most of Australia, beginning in Tasmania in 1953 and other states in the 1960s and 70s. The author of the 1936–1938 study noted the drop in the percentage of teeth classified as 'irreparable', and considered that this was due to the increased activities of school dentists and the improved means of transport of dental equipment.[4]

The DMFT index is a broad indicator of oral health. A score representing no dental disease, no restorations (fillings) and no missing teeth is indicated by DMFT = 0. A member with a full complement of 32 teeth and four restored teeth would have a DMFT = 4. A member with healthy teeth and no restorations but with all the third molars (wisdom teeth) removed would also have a DMFT score = 4. The worst possible score, indicating either decay or restoration in every tooth, or every tooth missing, or some other combination of these events, would be a DMFT score = 32. While this composite number does not allow this distinction to be drawn, the DMFT index can be split into its parts (i.e. D=2, M= 2, F= 1, DMFT= 5), in order to refine this detail better. While the DMFT index provides only a broad assessment of dental health, it was selected in part because of the limited data contained in the dental records of the crew of HMAS *Sydney* II.

A study of Royal Australian Air Force personnel[1] found that 57% of the mean DMFT score of 19.5 was attributable to missing teeth during 1939–1945. The present study suggests that the mean DMFT score on entry was far lower in the RAN in the 1930s (see below). However, more of it was accounted for by missing teeth (78%). Those with a higher DMFT score were more likely to have the majority proportion of the score accounted for by missing teeth in the *Sydney* II population. In contrast, in the modern sample, the majority with a DMFT score greater than 4 was accounted for by decayed and restored teeth. A study of RAN recruits in 1988[2] found mean DMFT scores of 4.33, 6.85 and 8.87 for members aged 15–19, 20–24 and 25–29 respectively. By comparison, the 1930s cohort represented by *Sydney* II demonstrates mean DMFT scores of 5.3, 7.3 and 13.0 for the same age ranges. The vast majority of missing teeth in the *Sydney* IV population were third molars and first or second premolars, likely extracted for orthodontic reasons rather than due to decay. In contrast, the most commonly extracted (or tooth charted as missing) in the *Sydney* II population was the first molar. This is not unexpected, as it is usually one of the first adult teeth to erupt around age six.

In contrast to the DMFT index, the T-health index[5,6] is a composite indicator of oral health, based on the DMFT score, that provides an overall indicator of dental *function*. It weights missing teeth higher than decayed teeth, which are similarly weighted higher than filled teeth in order to reflect the progressive loss of function from restored through to missing teeth. The index is a reasonable indicator of dental function when compared to self-rated scales, providing that the weight of a decayed tooth is approximately twice that of a filled tooth with an assigned weight of less than 0.2. In this study, these recommendations were followed by assigning weights of 1.0, 0.2, 0.1 and 0 for sound, filled, decayed and missing teeth respectively. The highest T-health score possible is 32, suggestive of full function with a completely present and unrestored dentition. The mean T-health score in the *Sydney* II population was 25.5, compared to 27.8 for the *Sydney* IV group. It was surprising that there was a relatively small difference between the two cohorts' mean T-health scores in this study. However, when considering the age-distributed pattern of caries, and the population's age distribution, this appears logical, as most oral health function is lost in post-26-year-olds (see Figure 2). For members who were 26 years of age or older on enlistment, the relative T-health scores were 17.9 for *Sydney* II and 26.8 for *Sydney* IV.

Historical data of this nature has significant limitations and is beset with issues that make drawing definitive conclusions difficult. The majority of the dental records on entry appear to have been signed off by a Medical Officer. Many forms have the notation next to the dental chart 'Signature of Naval Dental Officer (if available)', and this is blank or crossed through. Historically, the dental examination on entry during World War II was often conducted with a penlight or torch as part of the medical examination, rather than in a proper dental facility. It is difficult to say how accurate a Medical Officer's charting may be under these conditions compared to that of a Dental Officer. Missing teeth and restorations (largely consisting of gold or amalgam at the time) are generally evident to those not trained in dentistry. However, the extent of decay is probably underestimated in this analysis as its detection is often difficult in the early stages, and one could assume that only obvious decay was likely to be recognised by the examining officer.

Additionally, no radiographic data were available for the *Sydney* II cohort. Contemporary dental examinations always consist of radiographic examination in addition to clinical examination by a Dental Officer, with radiographs able to confirm the presence or absence of teeth, particularly unerupted and hence unseen third molars in younger patients. It is unknown whether the recruits routinely had dental radiographs taken on entry—the record suggests that this was highly unlikely. It is more likely that decay has been underdiagnosed in the *Sydney* II population, as interproximal decay (between the teeth) is difficult to detect, particularly by non-dental clinicians, until the later stages. Individual factors such as diet and oral hygiene likely explain the rapid increase in decay prevalence seen in the over-26 population.

It is difficult to draw firm conclusions from cross-sectional caries data, as dental caries is a multifactorial disease whose epidemiology is affected by individual factors such as diet, fluoride exposure and personal oral hygiene practices. During dental development, geographic location also affects the former two of these, particularly fluoride exposure and acts as a secondary mediator that is impossible to account for in this study. Nevertheless, the use of DMFT score as a broad indicator allows a valid comparison between the crews' dental health of HMAS *Sydney* II and HMAS *Sydney* IV, representative of military populations in the RAN in the mid to late 1930s and today.

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Long Term Stability of Recall of Combat Exposure in Australian Vietnam Veterans

B O'Toole, S Catts

Abstract

Accurate recall of exposure to traumatic events is essential for diagnosis, treatment and compensation. However, in the context of military combat, reports of trauma exposure may not be stable over time. Increased reporting over repeated assessments has been associated with PTSD and its re-experiencing (B) symptoms. Other competing explanations emphasise poorer health. This study reports on 388 Australian Vietnam veterans who were interviewed 21 and 36 years after repatriation. Combat exposure was assessed using a 21-item American scale. PTSD and the symptom clusters were assessed with standardised psychiatric diagnostic interviews, and self-administered measures of health were included. Although total combat scores were highly correlated across the two assessments (r =.865), stability of individual items differed widely.

Sixty-eight per cent of responses were stable, 17.5% were unstable increased reports, and 14.5% were unstable decreased reports. In hierarchical regression analyses, combat was the strongest predictor of stable reports but a weaker predictor of increased and decreased reports. Having a history of PTSD, particularly intrusion symptoms, significantly predicted stable reports. A history of PTSD was a significant but weaker predictor of increased reports of combat exposure. Suggestions of intrusive symptoms and poorer health as explanations of increased reports of exposure were not supported.

Introduction

Exposure to traumatic events is central to the diagnosis of post-traumatic stress disorder (PTSD). Unless objective evidence of trauma exposure is available, accurate subjective recall of exposure is essential for scientific, diagnostic, legal and compensatory purposes. However, recall accuracy of exposure to traumatic events has come into question from studies of US veterans. In a military context, an early report by Janes et al. (1991)[1] that evaluated reliability and validity of a combat stress scale over two assessments two years apart using members of the Vietnam Twin Registry, showed that reports tend to be reliable and, when compared with combat medal status, also tend to be valid. However, the accuracy of reporting combat events was questioned when articles began to appear that indicated the recall of combat exposure in US military veterans was potentially affected by PTSD itself.[2, 3] In particular, it was reported that PTSD in veterans increased the reporting of exposure to events when veterans were assessed on a second occasion. For example, Southwick et al.[2] reported findings from a small study of 59 returnees from a four-month tour of duty in Operation Desert Storm. Subjects completed questionnaires one month and 24 months after return, showing that 52 changed responses on at least one item, 36 changed at least two, and 41 recalled an event at 24 months that they did not report at one month. There were positive correlations between changes in recall and scores on the Mississippi Scale for PTSD[4] that they proposed were due to the effect of intrusive symptoms.

Roemer et al.[3] reported results of a larger study of 460 returnees from Somalia who completed questionnaires within 12 months of return and who were interviewed by telephone one to three years later. Using a 7-item scale, they found that there were significant increases in reports of war-zone exposures from time 1 to time 2, which, in a hierarchical regression, were related to a composite PTSD measure. Subsequent analysis found that of the syndromal subscales assessed using the Posttraumatic Checklist (PCL),[5] the intrusion subscale was significantly related to changes in reports. These reports preceded a much larger study by Koenen et al. in 2007,[6] of Vietnam veterans who were first assessed in 1984, nine years after the end of the war, and re-assessed in 1998—an average of 14 years later. Using an eight-item checklist of Likert scale combat exposures, they computed scores based on the total number of changes of exposures from 'ever' exposed to 'never' exposed, and from 'never' to 'ever', as well as scores of the total number of changes. Assessed against a 17-item self-report PTSD symptom scale, they found that increases in intrusion symptoms, but not avoidance or arousal, were positively and significantly associated with changes from non-endorsement to endorsement (i.e. 'never' to 'ever' responses), and concluded that changes in reporting of exposures were positively associated with PTSD symptoms, with intrusive memories driving veterans' increased later reports. More recently, Garvey Wilson et al.[7] followed returnees from Iraq, surveying them three, six and 12 months after return. They found 80–90% agreement in combat exposure reporting; however, PTSD was only 'slightly' (sic) associated with increased reporting.

However, findings of the effect of PTSD on reporting have not been consistent. King et al.[8] reported a questionnaire assessment of 2 942 Gulf War veterans who completed self-administered questionnaires within five days of return and 18–24 months later. The questionnaires contained a 31-item war-zone stressor scale (with binary Yes/No questions) and the Mississippi PTSD scale. They found that the majority of changed responses were of non-endorsement to endorsement ('never' to 'ever'). Using a cross-lagged panel analysis, they reported that combat reports at time 2 were primarily accounted for by combat reports at time 1, but less so by PTSD symptoms at time 1. In another study of 137 Dutch peacekeepers[9] who deployed for an average of 5.6 months in Cambodia, and who were surveyed twice—three and four years after return—changes in self-reports of exposure were not associated with PTSD measures. A study of UK veterans[10] who had served in the Persian Gulf War (n = 907) and in Bosnia (n = 638) surveyed veterans six years after the close of the first Gulf War and then three years later, reported that remembering more exposures over time was associated with worse perception of health but not with measures of mental health or PTSD symptoms.

In the face of these conflicting findings, doubts remain as to whether subsequent reports of combat trauma exposure are inflated and, if so, the extent to which PTSD and its component symptom clusters are responsible. The difficulty with interpretation of these varying results arises because (i) there were variations in the methods of assessment (mostly self-administered questionnaires) and symptoms of PTSD were assessed in the past month (i.e. the focus was on current PTSD); (ii) there were profound differences in exposures associated with the theatres of deployment and thus the potential for experiencing extremely traumatic events; (iii) there were differences in the period between exposure and assessment, from five days after return from a combat zone to nine years; (iv) there were large differences in the periods between assessments, from 12–24 months through 14 years; (v) there were significant differences between the types of service personnel (including Military Police and medical staff in the Southwick et al. study and combatants in the Koenen et al. study), and there were differences in the assessments of PTSD symptomatology. Any or all of these could potentially impact the observed variability of the findings. For example, if traumatic memory consolidation occurs over time, and is subject to intrusive phenomena, this might predict more stable reports of exposure as the memory is rehearsed. So, measures taken years after exposure, rather than sooner, may show smaller variability at a second subsequent assessment and thus more stable trajectories over time for people with PTSD. It is also possible that people with PTSD are reticent to disclose and may be less willing to endorse questionnaires at the first enquiry, so if under-reporting occurred at time 1 this itself might be an epiphenomenon of PTSD.

A number of factors associated with PTSD may impact the stability of recall of exposure to traumatic events. For example, risk factors for PTSD include intensity of combat exposure, education level and IQ, rank, military trade or job (such as infantryman, field engineer, artillery, medic) and becoming a battle casualty.[11] The role of these in the PTSD-recall relationship has not been addressed in the literature. It might be expected that recall may be more accurate for combatants with higher education or intelligence levels, or for events that lead to combat injuries, and these may confound the PTSD-recall relationship. The course of PTSD over time has not been considered in previous studies, so that if PTSD is associated with increased recall but has resolved over time, then the effect of PTSD should also have waned by the time of a second assessment. However, the question of the stability of recall of combat exposure has not been assessed together with changes in PTSD over time.

Uncertainty also remains as to whether stability and change are associated with other factors unmeasured and uncontrolled for in previous studies, such as intelligence, the actual level of combat, or poor health as suggested by the UK results.

While research has been focused on increases in recall over time, it is often overlooked that many reports remain stable over time; claims of an event occurring or not occurring are often recalled precisely, sometimes many years later in all of these studies. It is obvious that not having combat-related PTSD may be associated with stable reports of non-exposure. However, having PTSD may reinforce memories through the intrusion symptoms that act as reminders (Roemer et al., 1998), with a PTSD diagnosis, therefore, possibly associated with more stable reports of exposure.

This article presents data from a longitudinal cohort study of Australian Vietnam veterans who were assessed at similar time intervals to the Koenen et al. study[6], and which incorporates the longitudinal course of PTSD and its symptom clusters, a measure of health status, and statistical control of potential confounding. To overcome potential misclassification weaknesses of self-administered questionnaires, the study used in-person interviews and standardised diagnostic assessments to assess PTSD and examine its relationship with the recall of combat experiences.

The aims of the study were:

- to assess the levels of stable and unstable reports of combat exposure over a 14-year interval in Australian Vietnam veterans
- to establish whether the level of combat, changes in PTSD and symptoms, and perception of health are associated with stable and unstable reporting
- to test whether the course of PTSD and its symptom clusters, and perception of health, is significantly associated with stable or unstable reports of combat exposure after accounting for level of combat and potential confounders.

Method

A simple random sample[12,13] of 1000 male Australian Army Vietnam veterans was selected from personnel files held by the Army and interviewed in-person between July 1990 and February 1993 (n = 641) an average of 21.96 years (SD = 1.91) after repatriation, and again between April 2005 and November 2006 (n = 450), an average of 36.10 years (SD = 1.92) after return, with an average inter-interview interval of 14.18 years (SD = 1.92). Three-hundred and ninety-one veterans were interviewed on both occasions, but due to missing data in some items, the cohort sample size was reduced to 388.

Interviews were conducted in wave 1 by the first author and other members of the research team, by volunteer clinician counsellors recruited from the Vietnam Veterans Counselling Service (VVCS) and by volunteer officers from the Australian Army Psychology Corps. Interviews in wave 2 were conducted by the first author and by clinician counsellors recruited via their affiliation with the VVCS or the (then) Australian Centre for Military and Veteran Health. Interviews lasted between four and six hours and took place across Australia in veteran-nominated locations (usually their own homes).

Ethics approvals were obtained in the first wave from the Human Research Ethics Committees (HRECs) of the University of Sydney and the University of Queensland, and in the second wave from HRECs at Sydney University, the Concord Repatriation General Hospital in Sydney, the Australian Department of Veterans Affairs and the Australian Institute of Health and Welfare. Interviewers were trained in residential sessions in Sydney (wave 1) or interviewers' home cities (wave 2).

Measures

In-person assessments comprised a general health interview, completion of self-administered questionnaires during the interview, and assessment of combat and PTSD. The content of the interviews included (i) a 21-item Vietnam combat index developed in the USA[14] that was not used in the formulation of the diagnosis of PTSD but served to set the scene for the description of DSM Criterion A Vietnam events; (ii) assessment of combat-related PTSD using the Structured Clinical Interview for DSM-III (SCID)[15] in wave one and the Clinician-assessed PTSD Scale for DSM-IV (CAPS-4)[16] in wave two. The CAPS used the standard F1/I2 symptom criteria (Frequency > 1, Intensity > 2)[17]. These diagnoses were used to chart the course of PTSD into three groups: (1) veterans who had never qualified for a diagnosis of PTSD; (2) veterans who had a history of PTSD that was not current at wave two and thus could be considered to be in remission; and (3) veterans who had qualified for a diagnosis of PTSD that was current (one month) PTSD at the time of wave 2 interviews (for details see reference 11).

The Vietnam combat index asked the frequency of experiencing each of 21 events, with response categories of never, once, 2–5 times, 6–10 times and more often. Frequency scores were computed as 0–4 for each item, with a possible total ranging between 0 and 84 (the items are shown in Table 1). The study extracted data from Army records, including rank, enlistment and deployment details, and the Army General Classification Test (AGC), a 100-item test of intelligence comprising mixed spatial, numerical and verbal items shown in this cohort to be related to risk of PTSD.[11]

The Medical Outcomes Study 36-Item Short Form Health Survey(SF-36)[18] was administered during the interview. This questionnaire comprised 36 items that assess eight health concepts: (1) limitations in physical activities because of health problems; (2) limitations in social activities because of physical or emotional problems; (3) limitations in usual role activities because of physical health problems; (4) bodily pain; (5) general mental health; (6) limitations in usual role activities because of emotional problems; (7) vitality; and (8) general health perceptions. These scales are combined to produce summary scores, a Physical Component Summary (PCS) of 21 items and a Mental Component Summary (MCS) of 14 items[19]. (Note that item 2 is not included in the summary scores). Low scores on each scale indicate poor health status. The SF-36 summary scales demonstrated high internal consistency; Chronbach alpha scores for the PCS and MCS were.951 and.930, respectively.

Data analysis

Initial analysis was directed to assessing potential response bias by comparing Army record data of veterans who participated in both waves of interview with all known alive veterans and with veterans who dropped out after wave one. Wave one diagnoses also were compared for veterans who participated twice with those who dropped out after wave one. Over the two waves of assessments veterans were classified into those with no PTSD diagnosis, those with a history of PTSD that was not current at the second assessment, and those who had current PTSD at wave 2.11 Using a similar algorithm, the course of intrusion (B) symptoms, numbing/avoidance (C) symptoms, and arousal (D) symptoms were classified according to whether the veteran had ever met the criterion, and whether the criterion was met currently at the second assessment (no criterion, history of meeting criterion, currently met criterion). This enabled a more refined analysis of the course of component symptoms in addition to the overall PTSD diagnosis.

Changes in combat index items were assessed from crosstabulation of wave 1 with wave 2 item responses. Kappa statistics were computed to assess agreement across waves for each item. Difference scores were computed for each of the 21 combat scale items by subtracting the second score from the first and then summing to produce an overall wave 1 minus wave 2 difference score (W1 – W2 difference score). All items were then recoded into binary ('ever' and 'never') scores, indicating endorsement or non-endorsement of each item. The following scores were then computed that mirrored those of Koenen et al.:[6]

- stability scores: the number of items unchanged (both 'never' and 'ever' responses)
- change scores: the number of items changed from 'never' to 'ever' and 'ever' to 'never'.

In the first step of the analysis, each of these four change scores was tested for a significant relationship with potentially confounding variables known to be related to PTSD.11,[20] These were Military Corps (job or 'trade', such as Infantry, Armour, Artillery, Medical, etc.), intelligence (Army AGC test), age at (first) deployment, rank in Vietnam, conscript or volunteer enlistment, duration of Vietnam service and whether the veteran had been injured in combat.

The course of PTSD over the 14 years between waves (no PTSD, history of resolved PTSD, current and chronic PTSD at wave 2) was tested for bivariate relationships with stability and change scores using analysis of variance with tests for linear and quadratic trend. The course of each of the B, C and D symptom clusters' diagnostic criteria were similarly classified into three: (1) never meeting the criterion symptoms; (2) a history of meeting the criterion symptoms; and (3) meeting current criterion symptoms. Analysis of variance was used to assess each for stability and change in recall as a function of symptom course, again testing for linear and quadratic trends. Pearson correlation coefficients were computed between change scores and the summary scales of the SF-36 to test for a relationship between health status at the second assessment and stability and change in recall. Finally, a series of sequential hierarchical linear regression models were computed for each change endpoint. Because the PTSD diagnosis and symptom course variables were categorical, dummy variables were computed for entry into the multivariate analyses with the category of no PTSD serving as the reference. The first model entered potential confounders, the second model entered wave 1 combat, the third model entered the PTSD course or the B, C and D symptom courses together, and in the final model the two summary SF-36 scales were entered together. In this way, the effects of each variable set could be assessed after controlling for the previous ones. PTSD diagnosis and the symptom clusters were not entered together in the same model, to avoid issues of collinearity, but were analysed in separate modelling. Model R^2 change was examined to determine relative importance to each change score of each successive model.

Results

The age of veterans at wave 2 ranged from 46 to 87 years (M = 60.50 years, SD = 5.34); veterans were mostly married (prevalence = 87.9%) with only few (3.4%) never married; 83.5% were in possession of a treatment entitlement card issued by the Australian Department of Veterans Affairs (DVA) that indicated acceptance of a war-caused disability; and 60.9% reported that their main source of income was a DVA pension. The prevalences of lifetime and current (one month) PTSD were 22.9% and 13.7% respectively in wave one, and 31.2% and 20.4% in wave 2.[11]

Multivariate analysis of Army record data comparing respondents who were interviewed twice with all known alive non-respondents, and with wave 1 interviewees who did not participate in the second interview, revealed only two significant items: the AGC for respondents was significantly higher than that for alive non-respondents, and non-respondents had more charges of AWOL after return to Australia. This suggests that cohort respondents were generally more intelligent and more engaged, and is consistent with non-response analysis at wave 1[20] and wave 2.[21] There were no significant differences between wave 1 veterans who dropped out and those who participated twice, either in terms of Army-derived data or wave 1 psychiatric diagnoses including PTSD.

Means for the combat scale totals for waves 1 and 2 were 20.80 (SD = 4.07) and 21.16 (SD = 4.14) respectively, and ranges and medians were 0–82 and 18.0 for wave 1 and 0–75 and 19.0 for wave 2. The two combat scales had high individual internal consistencies (Chronbach α =.930 and .935 at Time 1 and 2 respectively) and they were highly correlated (r =.865, p <.001). A two-tailed t-test of whether the (W1 – W2) mean difference score between wave 1 and wave 2 varied significantly from zero was (t_{387} = -3.530, p <.001) indicating significant tendency overall to an increase in combat item response categories from wave 1 to wave 2.

Table 1. Prevalence of endorsement for each item of the combat index in both waves, item changes between waves 1 and 2 and kappa statistics assessing correspondence between the waves.

	Per cent Ever		Per cent Unchanged	Per cent Changed		$\varkappa$*
	Wave 1	Wave 2		Never-Ever	Ever-Never	
1. Make contact with the enemy	69.0	72.9	92.5	1.8	5.7	0.82
2. Fire weapon at the enemy	58.7	73.6	77.7	18.6	3.6	0.52
3. See Vietnamese killed	45.5	62.0	70.1	23.3	6.7	0.41
4. See our men killed	31.0	56.1	64.1	30.5	5.4	0.31
5. See enemy wounded	61.0	35.4	58.9	7.8	33.3	0.23
6. See our men wounded	66.4	61.5	72.3	11.4	16.3	0.40
7. See dead enemy	72.4	69.5	72.9	12.1	15.0	0.34
8. Kill the enemy	26.9	72.6	53.7	46.0	0.3	0.24
9. See dead civilians	49.9	30.2	60.3	10.1	29.7	0.20
10. See our own dead	56.8	49.9	63.1	15.0	22.0	0.26
11. Felt may never survive combat	45.5	51.7	62.3	22.0	15.8	0.25
12. Participate in body count	29.2	50.1	62.0	29.5	8.5	0.24
13. Directly hurt Vietnamese	24.3	26.9	76.2	13.2	10.6	0.38
14. Burn, destroy villages	17.1	15.8	78.0	10.3	11.6	0.20
15. Observe killing Vietnamese	27.6	15.8	73.2	7.5	19.4	0.23
16. Risk of being killed, wounded	87.6	25.1	35.9	0.8	63.3	0.07
17. See our men wounded by antipersonnel devices	39.8	52.5	84.2	14.2	1.6	0.69
18. Directly kill Vietnamese	36.4	36.4	66.9	16.5	16.5	0.29
19. Observe Vietnamese being hurt	25.8	32.0	70.5	17.8	11.6	0.29
20. Direct involvement in mutilation	3.6	15.8	83.8	14.2	2.1	0.11
21. Observe mutilation	12.7	8.8	87.3	4.4	8.3	0.34

* All $\varkappa$ values are statistically significant (p <.005)

There were many changes in individual item responses between the waves. Table 1 shows the items in the scale, the percentage of veterans who reported that the event occurred at least once, the per cent that was unchanged, that were changed from 'ever' to 'never' and 'never' to 'ever', and the kappa statistics comparing each item scored as binary ('never' vs 'ever').

Several features stand out in the table: Firstly, the percentage of responses that remained unchanged between waves 1 and 2 varied markedly across items. Veterans were highly likely to be consistent in reports of enemy contact and either (not) witnessing or (not) being directly involved in acts of mutilation, and seeing men injured by antipersonnel devices, but other items varied widely. Item 8 (kill the enemy) saw a large increase in positive reports from wave 1 to wave 2, as did item 4 (see our men killed) and item 12 (participate in a body count), item 3 (see Vietnamese killed) and item 11 (never survive combat). In 11 of the 21 items, there was an increase in the number of veterans who claimed to have experienced it. However, many initially positive reports remained positive, and many initially negative reports remained negative. There were also large numbers of initially positive reports that were changed to negative ones: item 16 (subjective risk of being killed or injured), item 5 (see enemy wounded), item 9 (see dead civilians) and item 10 (see our own dead) were all changed negatively in more than 20% of reports at wave 2. Thus, while there was a high correlation between total scores from wave 1 to wave 2, examination of the behaviour of individual items revealed marked differences in their stability.

The 21-item combat index presented the opportunity for up to 21 stable or unstable responses. Overall, 40.1% were stable 'never'-'never' responses, 28.0% were stable 'ever'-'ever' responses, 17.5% were unstable 'never'-'ever' responses, and 14.5% were unstable 'ever'-'never' responses. Therefore, more than two-thirds of responses were stable over time, while unstable increases and decreases were at similar levels.

Table 2. Means and standard deviations of combat index change scores for the 14-year course of PTSD diagnosis and each diagnostic symptom cluster (intrusion, numbing/avoidance and arousal).

	Unchanged Never-Never		Unchanged Ever-Ever		Changed Never-Ever		Changes Ever-Never	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PTSD Diagnosis								
No PTSD	10.24**	5.72	4.12 **	4.62	3.42*	2.12	3.11	2.06
History only	6.63	4.84	6.91	5.15	4.26	2.32	2.94	1.90
Current PTSD	4.58	3.78	9.81	5.55	3.75	2.55	2.85	2.2
Intrusion (B) criterion met								
No symptoms	12.33***	5.45	2.65 ***	3.48	2.94 **	1.97	2.87	1.98
History only	8.38	5.08	5.16	4.72	3.93	2.14	3.23	1.93
Current symptoms	6.23	4.97	7.61	5.69	3.86	2.41	2.99	2.17
Numbing/Avoidance (C) criterion met								
No symptoms	10.46 ***	5.76	4.06 ***	4.67	3.25 **	2.02	3.12	2.05
History only	6.95	4.84	7.05	4.84	4.16	2.32	2.84	1.89
Current symptoms	5.34	4.45	8.10	5.86	4.00	2.56	2.88	2.19
Hyperarousal (D) criterion met								
No symptoms	11.73 ***	5.38	3.03 ***	3.65	3.16 **	2.06	2.90	1.98
History only	7.32	4.99	5.53	4.50	4.32	2.28	3.29	1.94
Current symptoms	6.31	5.04	7.59	5.77	3.80	2.38	3.01	2.15

* $p<.05$, ** $p<.01$, *** $p<.001$

Table 2 shows the means and standard deviations of change scores for the course of PTSD diagnosis and each criterion B, C and D symptom clusters. All analyses returned significant linear (but not quadratic) trend except for increased 'never-ever' scores. Thus, unchanged stable reporting of 'never-never' and 'ever-ever' exposures were associated with PTSD diagnosis and all symptom clusters, with PTSD diagnosis and clusters associated with fewer stable 'never-never' responses and more stable 'ever-ever' responses. Changed unstable reports from 'never' to 'ever' were associated with PTSD diagnosis and all symptoms clusters but not linearly. The significant quadratic (but not linear) trend indicated higher unstable scores among veterans who had PTSD that was not current at wave two (i.e., had remitted).[11] Unstable changes from 'ever' to 'never' were not associated with any diagnosis or symptom course.

Pearson correlation coefficients between the combat index, each of the SF-36 PCS and MCS scale scores and each of the change scores are shown in Table 3. Note the pattern of positive and negative directions of the significant correlations. Combat was strongly positively correlated with stable 'ever' response scores, and negatively correlated with stable 'never' scores. This suggests that stable responses of no exposure are associated with lower combat, and stable responses of actual exposure are associated with higher combat. Combat was also weakly negatively correlated with unstable 'ever-never' scores, but positively correlated with unstable 'never-ever' response scores. The SF-36 scales were associated with stable reports but in opposite directions. This suggests that poor health may be associated with fewer stable 'never-never' reports and more stable 'ever-ever' reports. SF-36 scales were not significantly correlated with unstable reports.

Potential confounders of predictors of recall

Intelligence test scores were not related to any change scores, nor were years of education, age at first deployment, serving in Infantry in Vietnam, or serving as an officer in Vietnam. Lower rank was associated with fewer stable 'never-never' and more stable 'ever-ever' responses, but not associated with unstable responses. Enlistment via conscription was associated only with more unstable 'never-ever' responses; however, becoming a battle casualty was associated strongly with fewer stable 'never-never' and more stable 'ever-ever' responses, but not with unstable responses. Corps group (representing the military job or trade - Infantry, Engineers, Medical, etc.) was associated with stable but not unstable responses.

Multivariate analysis of stable and unstable reports

To assess the relative contributions of combat, the course of PTSD symptom clusters and poorer health to stable or unstable reporting, sequential hierarchical regression modelling was undertaken with each outcome variable as dependent. Each model was adjusted for potential confounding variables appropriate for each endpoint: rank in Vietnam, sustaining a battle casualty, and corps for stable responses, and enlistment method (conscript versus volunteer) for unstable 'never'-'ever' responses. Since no potential confounding variable was associated with unstable 'ever'-'never' responses, adjustment was unnecessary. (Note the definition of a confounding variable[22] specifies that the variable is associated with the dependent and the independent variable, which warrants adjustment in analysis—if there are no confounders then adjustment is not warranted).

Table 3. Pearson correlation coefficients between the wave 1 combat index, wave 2 SF-36 summary scales and each of the stable or unstable change scores.

	Number unchanged		Number changed	
	Never-Never	Ever-Ever	Never-Ever	Ever-Never
Wave 1 Combat index	-.827**	.914***	-.173**	.106*
SF-36 Summary Scales:				
Physical Health	.273**	-.267**	-.080	-.045
Mental Health	.298**	-.280**	-.098	-.045

* p <.05, ** p <.01, *** p <.001

Table 4. Changes in R^2 for regression models as each item block was added sequentially to models of total unchanged (never-never and ever-ever) and total changed (never-ever and ever-never) response scores, and standardised regression coefficients for the final models.

(1) Model A with PTSD diagnosis	Unchanged Never-Never	Unchanged Ever-Ever	Changes Never-Ever	Changes Ever-Never
	Changes in Adjusted R^2			
Confounders	.131***	.165***	.019**	-
+ Combat index	.558***	.676***	.024**	.009*
+ PTSD course	.010**	.005**	.039***	.011
+ Wave SF-36 subscales	.001	.000	.010	.002
Total Adjusted R^2	.701	.842	.077	.022
	Final Models: Standardised Regression Coefficients (β)			
Combat	-.761***	.854***	-.241***	.141*
Course of PTSD:				
- History of PTSD	-.084**	.020	.173**	-.072
- Current PTSD	-.067	.075**	.112	-.121
SF-36 summary scales:				
Physical Health	-.033	.003	-.073	-.043
Mental Health	.074	-.002	-.036	-.004
(2) Model B with Symptom Clusters	**Unchanged Never- Never**	**Unchanged Ever-Ever**	**Changes Never-Ever**	**Changes Ever-Never**
	Changes in Adjusted R^2			
Confounders	.131***	.165***	.019**	-
+ Combat index	.558***	.676***	.024**	.009*
+ B, C & D symptom course	.023***	.004	.083***	.027
+ Wave 2 SF-36 subscales	.001	.000	.001	.000
Total Adjusted R^2	.713	.845	.107	.036
	Final Models: Standardised Regression Coefficients (β)			
Combat	-.733***	.866***	-.300***	.095
B symptoms course:				
- History of B symptoms	-.091*	-.019	-.118	-.089
- Current B Symptoms	.032	.027	-.045	.076
C Symptom Course:				
- History of C Symptoms	-.041	.033	.089	-.078
- Current C Symptoms	-.087	.041	.165*	-.106
D Symptom Course:				
- History of D Symptoms	.016	.012	-.056	-.048
- Current D symptoms	-.037	-.023	.019	.026
SF-36 summary scales:				
Physical Health	-.047	.012	-.036	-.030
Mental Health	.054	-.016	-.001	.017

* $p < .05$, ** $p < .01$, *** $p < .001$

The analysis strategy first introduced the course of PTSD in the regression modelling without the symptom cluster data (model A) and in the second series of models then introduced the symptom cluster courses without the full diagnosis (model B). This was undertaken to check whether the diagnosis itself was significant and, if so, whether some individual symptoms were more important than others. Entering the diagnosis as well as the symptom clusters would introduce significant multicollinearity, as the symptom clusters were integral to the diagnosis itself. Table 4 shows the change in R^2 at each step of the modelling and the standardised regression coefficients for variables in the final models for each change variable.

Combat was a strong predictor of stability but a weaker predictor of instability. After accounting for combat, the course of PTSD diagnosis added significantly to both of the stable responses and the unstable 'never-ever' responses but not to unstable 'ever-never' responses. The final model's significant variables for stable 'never-never' responses included combat and a history of PTSD but not current PTSD. In contrast, the final model's significant variables for stable 'ever-ever' responses included current PTSD but not a history of PTSD.

A history of B symptoms, but not current B symptoms, were significant in the final model for stable 'never-never' responses, but C and D symptom courses and SF-36 scores were not significant. Thus, lower combat was associated with more stable reports of 'never-never' experiencing traumatic combat events. The significant variables in the final model for stable 'ever-ever' responses included combat and PTSD diagnosis with current PTSD being significant, but not B, C or D symptoms. Thus, higher combat and current PTSD were significant associates of more stable 'ever-ever' reports.

The significant variables in the final model for unstable 'never-ever' reports included combat (with a negative parameter estimate that indicates PTSD is related to fewer increased reports) and current C symptoms. This is inconsistent with previous explanations of increased reporting as a function of intrusive symptoms.[2, 3, 6] This is also inconsistent with the hypothesis that increased reporting of combat exposure is more closely associated with poor health.[10] Finally, unstable 'ever-never' reports had no significant individual variables in the final model except combat. SF-36 summary scales made no significant further contribution to stable or unstable scores after controlling for PTSD or its symptom clusters.

Discussion

This study has confirmed that increased reporting of combat exposure may occur when veterans are asked on several occasions, even three decades after the war ended, and 14 years after they first told their stories. This adds to evidence that increased reporting may occur over the first 12 months after return,[7] may be observable over 2–3 years after return,[2, 3, 8] 6–9 years after return,[10] and be measurable a further 14 years later.[6] In Australian Vietnam veterans assessed more than 20 years after their service in Vietnam and again 14 years later, recall of combat exposure over time was characterised by both stability and change. Stable reporting of non-exposure to traumatic combat events was highest in veterans with lower combat exposure, as may be expected. Stable reporting of exposure to combat events was higher in veterans with high combat exposure and with current chronic PTSD. Veterans with higher combat were less likely to change their responses from 'never' to 'ever' but also more likely to change their responses from 'ever' to 'never'. Therefore, it seems that combat, rather than development of PTSD, may be the driving factor in stable reporting, while increased reporting over time may be associated with lower combat. In using scales of combat or trauma exposure, there is a set of implicit assumptions that the measures are adequate (that veterans are able to recall events), reliable (that veterans give the same answer on subsequent occasions) and valid (that veterans' answers are accurate).

However, these assumptions may be tenuous. In some individual circumstances, it may be difficult to attribute a sufficiently high level of adequacy of responses. For example, questioning an individual about whether they actually killed an enemy combatant in a firefight might present an impossible question—during enemy contact an individual might fire their weapon at the enemy but, in jungle or urban warfare, might not actually see where any of their bullets hit. After the contact is concluded and an enemy body is discovered, it might be impossible to tell which soldier's fire was responsible, making it impossible for an individual combatant's report to be objectively verified later.

Without corroborating witnesses, for some briefer combat item scales that ask only general items (e.g. service in a war zone, service in combat) as used in previous US studies, it may be possible to validate some answers using external sources of information[1, 23, 24] such as media reports, which may themselves not be entirely accurate. Validating military records themselves may not be accurate due to missing or incomplete data entries.

Australian field commanders' diaries may be referred to (in official reports such as official war histories) that specify the units present at the time, but it may be uncertain exactly which soldier was present at the time and location, since any individual unit at any time may have had soldiers on leave, sick or assigned temporarily to other duties in different locations. Therefore a field commander's diary might specify precise location and duration of contact but be unable to confirm who was present during a specific instance of combat.

In most studies, test-retest correlations have been moderate to high.[1, 6, 8] In this study, it was high although there was a degree of change among individual items. A high test-retest correlation of total scale scores does not exclude the possibility that a similar scale score may be achieved in the midst of changes in individual items so that the total amount of combat exposure would not be as unstable. Several methodological differences have distinguished the reports discussed above. One is the method of assessment—it is possible that the studies using self-administered questionnaires have merely reflected lower levels of reliability compared with face-to-face methods.[25] PTSD diagnoses in the current study were collected in standardised face-to-face interviews rather than self-administered questionnaires, which would act to enhance data quality.

Explanations of increased reporting in terms of current B (intrusion symptoms) and poorer health were not supported; instead, history of PTSD and having current C symptoms were associated with increased reports. In fact, the B symptoms were significant predictors of stable negative reporting and were not associated with increased reports or with stable positive reports. In contrast, the C (numbing/avoidance) symptoms were more closely related to increased reporting. These symptoms include efforts to avoid thoughts, feelings or conversations associated with trauma, efforts to avoid activities, places or people who arouse recollections of trauma, as well as psychogenic amnesia—the inability to recall significant aspects of the event. It is possible that this avoidance acted to suppress initial memories and thus reporting of combat events at first interview.

Remaining uncertainty surrounds the question of whether the first or the second report is the more valid response. If having PTSD acts to inhibit reporting of events when first questioned, this will result in withholding of exposure reports that, as they become less painful over time, are more willingly admitted on a second occasion rather than denied. In reporting changes from 'never' to 'ever', it is feasible that veterans may have tended not to disclose all aspects of combat-related, potentially traumatic events but may have been less inhibited in doing so many years later. Reluctance to report events initially was also recognised by Roemer et al.[3] as potentially accounting for subsequent increased reports. If this is the case, it is possible that under-reporting at time 1 itself may be an epiphenomenon of PTSD so that, as reports become more accurate over time, it appears that they inflate later exposure reports. In addition, certain items in an exposure inventory (such as the risk of being killed or injured) may, on reflection over the years, appear to have been less severe than initially estimated (after all, the veterans who participated actually did survive!).

The limitations of this study are shared with any epidemiological study of non-treatment-seeking populations and comprise potential participation bias, measurement bias and confounding. Participation bias was assessed by comparing responders and non-responders, finding that the participants were intellectually brighter on average with fewer AWOL charges after return than non-responders, which may have influenced the reportage changes. Measurement used standardised instruments, in an attempt to minimise interviewer bias and to provide continuous measures that confer higher statistical power. Confounding was addressed in statistical analysis that sought potentially disturbing variables to the outcome variables; for example, there was no association between intelligence and changes in reporting. Multivariate analysis was used to assess the relative importance of PTSD, its symptom clusters and general health in stable and unstable reporting while controlling for confounders. However, the findings may be applicable only to war veterans, so that the results are in need of replication in other potentially traumatised groups, including civilians as well as military life.

An unaddressed concern is the role of compensation in reporting of exposure to combat events. In the context of compensation claims, it is possible that reports of combat exposure may be exaggerated.[24] However, the assessments of the veterans for the study were completely independent of the compensation process—the veterans were talking to researcher-clinicians, who had no role and could have no role in any compensation application for the veterans. Rather than a limitation, this would appear to be a strength of the study, in that reports were not made in expectation of compensation.

In conclusion, higher levels of combat were associated with stable reporting of combat exposure. Future research should consider stable as well as unstable reports of traumatic exposure when assessing change in reporting. In a clinical context, it is important to consider whether initial reports of trauma exposure tell the full story. In compensatory claims, it should be important not to dismiss potential overreporting of trauma exposure in subsequent assessments as a function of PTSD symptoms, but consider whether increased reporting itself is a function of the degree of trauma exposure.

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Testosterone and Vitamin D Concentrations in Military Personnel Following Traumatic Brain Injury

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Abstract

Background: Traumatic brain injury (TBI) has been shown to cause pituitary dysfunction, manifesting in low testosterone concentrations, and previous research suggests a link with vitamin D deficiency.

Purpose: To compare testosterone and vitamin D concentrations in service members with and without a TBI, and to identify the frequency of testosterone prescriptions.

Materials and methods: This retrospective de-identified medical review analysed assessments (testosterone, vitamin D) ordered for 4285 active duty and veteran military personnel at Womack Army Medical Center, Fort Bragg, NC from 2016–2018.

Results: Overall, 343 (8%) of service members had a medically diagnosed TBI. In all men, 19% were deficient in testosterone (<270 ng/dl), and 10% had a testosterone prescription. Active duty men with TBI history had lower testosterone than active duty men with no documented head injury (431 ± 162 vs 452 ± 170 ng/dl, *P* = 0.04). However, there was no significant difference in veteran men. More than one-third (38%) of all service members were insufficient in vitamin D (<30 ng/ml). Overall there was a weak positive correlation between testosterone and vitamin D concentrations in men but not in women.

Conclusions: Our research does not support evidence for high rates of hypogonadism, testosterone prescription, or vitamin D deficiency after TBI compared to military personnel without prior injury. However, we found a high prevalence of vitamin D insufficiency in active duty and retired service members independent of TBI, further supporting that vitamin D status should be assessed regularly in service members.

Key words: traumatic brain injury; vitamin D; testosterone; testosterone replacement therapy; military personnel

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Introduction

Traumatic brain injury (TBI) causes long-term consequences, including physical disabilities and behavioural, cognitive and psychological defects that may prevent military personnel from performing to their greatest potential and negatively impact long-term health.[1] Nearly half of TBI cases result in neuroendocrine dysfunction, characterised by hormone imbalances directly related to the hypothalamus and pituitary gland, and their axes.[2,3] Disruptions to the endocrine axes are caused by an inadequate supply of hypothalamic-releasing hormones or the pituitary gland's inability to produce hormones, both of which result in pituitary dysfunction.[4] Hypopituitarism with gonadotropin deficiency is one of the most prevalent types of neuroendocrine dysfunction following TBI and manifests as low testosterone concentrations.[1] In the immediate post-TBI period, low testosterone concentrations have been observed in up to 80% of individuals but resolve in the majority during the chronic phase 3 months after injury.[1,5] While neuroendocrine disorders have been well-established post-TBI, vitamin D's role is poorly understood, as evidence suggests vitamin D deficiency may be associated with TBI sequelae.[6] Vitamin D's neuroprotective role following TBI has been explored in several studies, most of which have used animal models.[7-9] It is unclear if TBI causes low vitamin D, or if low vitamin D prior to TBI exacerbates injury.[6-9]

Numerous studies have shown a decrease in testosterone or vitamin D concentrations following TBI in civilians.[9-14] Clinical hypopituitarism has been observed in all TBI severities. Hypogonadism and growth hormone deficiency are typically the most common pituitary abnormalities, although testosterone concentrations vary based on injury severity.[14,15] Four studies have investigated testosterone status in military personnel following mild, moderate, and severe blast-related TBI but did not report differences between severities.[2,16-18] Overall, these studies found low testosterone following injury, and one study found a significant decrease in testosterone three years after injury compared to controls. Civilian studies support high prevalence of vitamin D deficiency post-TBI, with one researcher identifying the lowest vitamin D concentrations in the most severe cases of TBI.[9-13] A few studies have established a positive correlation between testosterone and vitamin D concentrations in men, possibly due to the expression of the vitamin D receptor and metabolising enzymes in the Leydig cells of the testes.[19,20] Furthermore, Pilz et al.[20] found vitamin D supplementation in deficient males significantly increased testosterone compared to a placebo group. These data suggest that vitamin D has a supporting role in regulating testosterone production.[19]

No research to date has examined both testosterone and vitamin D status together after TBI in military personnel or civilians, despite the evidence that these hormone deficiencies may exacerbate post-concussive symptoms. Furthermore, research examining the use of testosterone replacement therapy following TBI is limited. Therefore, the purpose of this study was to compare testosterone and vitamin D concentrations between service members with and without a history of TBI and to identify rates of testosterone replacement therapy at a large military treatment facility. Characterising the incidence of TBI-related hypogonadism and vitamin D deficiency in military personnel helps to identify targets for therapeutic treatments to improve long-term recovery.

Methods

Study design and procedures

This retrospective de-identified medical review investigated testosterone and vitamin D status in active duty and retired service members, with and without a history of TBI, and the frequency of testosterone replacement therapy prescriptions.

Study population

The study population included 4285 veteran and active duty service members from the United States (US) military who had serum testosterone and vitamin D ordered and assessed at Womack Army Medical Center (WAMC), Fort Bragg, NC between October 2016 and December 2018. Appalachian State University Institutional Review Board approved this protocol, and a letter of agreement was established with WAMC. Inclusion criteria were current or previous military service, male or female, aged >18 years, with serum testosterone assessment.

Vitamin D was included in analysis if assessed at the same time as testosterone. Additional data collected from medical records included diagnosis of TBI, prescription for testosterone replacement therapy, date of hormonal assessments, and participant demographics: age, gender, and active duty/veteran military status.

Data analysis

All analyses were conducted with the statistical software package, Stata 15 (StataCorp 2017). Independent t-tests were used to identify differences between continuous variables. Chi-square tests were used to identify differences between dichotomous variables. A one-way ANOVA with Bonferroni post-hoc analysis was used to test for differences in vitamin D across seasons. Statistical significance was $P < 0.05$.

Results

Traumatic brain injury in service members

From 2016–2018, 4285 unique cases with testosterone assessments were identified, of which 3204 (75%) of participants were men, and 2675 (62%) were active duty. Overall, 343 (8%) of service members and veterans were diagnosed with a TBI between October 2016 and September 2018. One hundred and ninety-eight service members had a mild or moderate TBI diagnosis, while 143 service members had a TBI of unknown severity. Active duty personnel had higher rates of TBI compared to veterans (12 vs 2%, χ^2 (1, n = 4285) = 124, $P < 0.01$). Men were significantly more likely to be diagnosed with a TBI than women (10 vs 1%, χ^2 (1, n = 4285) = 93, $P < 0.01$).

Testosterone concentrations in service members

Overall mean total testosterone concentrations were 427 ± 179 ng/dl (range 5–800 ng/dl) for men and 31 ± 35 ng/dl (range 5-636 ng/dl) for women (Table 1). Of 3204 men who were assessed, 19% were deficient in testosterone (<270 ng/dl) according to the Army Medical Department Clinical Guidelines, and 25% were deficient according to the American Association of Clinical Endocrinologists Medical Guidelines[22] (<300 ng/dl); 10% of men had a testosterone prescription. Active duty men without testosterone prescriptions had significantly higher testosterone concentrations than active duty men with prescriptions (456 ± 163 vs 365 ± 225 ng/dl, $t = 5$, $P < 0.001$). As expected, active duty men had higher testosterone concentrations, lower rates of testosterone deficiency (by both clinical cut-offs), lower rates of testosterone prescriptions, and were younger compared to veteran men (Table 1). Women were younger with lower testosterone concentrations and lower rates of testosterone prescription than men. Of the 1081 women with testosterone assessments, n = 5 (3 active duty, 2 veteran) had high testosterone concentrations (279–636 ng/dl) but did not have testosterone prescriptions. Four women (1 active duty, 3 veteran) were prescribed testosterone, with similar formulations as those prescribed to male military personnel in this sample. Testosterone prescriptions consisted of gels, pellets, patches and injections of low and high doses (range 2.5–200 mg of testosterone). However, the exact dose prescribed per day is unknown. In men with a history of TBI, 15% (<270 ng/dl) and 22% (<300 ng/dl) had testosterone deficiency. By comparison, men without TBI had higher rates of testosterone deficiency (19% <270 ng/dl; 25% <300 ng/dl). This difference was statistically significant for testosterone <270 ng/dl only (χ^2 (1, n = 3204) = 4, $P = 0.039$). There were no differences in testosterone prescriptions between men with and without TBI (7 vs 10%, χ^2 (1, n = 3204) = 3, $P = 0.068$). Although total testosterone concentrations among all men (active duty and veteran) did not differ based on TBI history, active duty men with a history of TBI had lower testosterone compared to active duty men with no documented head injury (Figure 1; 431 ± 162 vs 452 ± 170 ng/dl, $t = 2$, $P = 0.035$). This difference was not significant in veteran men (Figure 1; 418 ± 138 vs 353 ± 190 ng/dl, $t = -2$, $P = 0.07$). When men with testosterone prescriptions were excluded from analysis, active duty men with a history of TBI still had lower concentrations of testosterone than active duty men without TBI but not at a significant level (440 ± 158 vs 458 ± 163 ng/dl, $t = 2$, $P = 0.07$). There were no significant differences in testosterone concentrations in women with and without a history of TBI (28 ± 20 vs 31 ± 35 ng/dl, $t = 0.50$, $P = 0.66$).

Table 1. Service member's testosterone, vitamin D, and history of TBI by sex and military status

	Active Duty Men ***(n = 2427)***	**Veteran Men** ***(n = 777)***	**Active Duty Women** ***(n = 248)***	**Veteran Women** ***(n = 833)***
Age (yrs)	37 ± 8^{AC}	54 ± 12^{B}	32 ± 8^{B}	33 ± 10
TBI	n = 301 (12%)^{ABC}	n = 30 (4%)	n = 9 (4%)	n = 3 (0.4%)
Testosterone (ng/dl)	450 ± 169^{ABC}	356 ± 189^{AB}	33 ± 42	30 ± 32
Testosterone Deficiency (<270 ng/dl)	n = 340 (14%)^{C}	n = 259 (33%)		
Testosterone Prescriptions	n = 169 (7%)^{ABC}	n = 155 (20%)^{AB}	n = 1 (0.4%)	n = 4 (0.5%)
Vitamin D (ng/ml)†	35 ± 12^{A}	35 ± 11^{B}	33 ± 11	32 ± 12
Vitamin D Insufficiency† (<30 ng/ml)	n = 365 (35%)	n = 127 (38%)^{B}	n = 39 (45%)	n = 127 (47%)

Data are presented as mean ± standard deviation for continuous variables †Not every subject had a vitamin D value (n = 1742). $^{A}P < 0.05$ vs active duty women. $^{B}P < 0.05$ vs veteran women. $^{C}P < 0.05$ vs veteran men. Active duty men had lower rates of testosterone deficiency using AACE Medical Guidelines (<300 ng/dl) compared to veteran men (19 vs 42%, χ^2 (1, n = 3204) = 166, $P < 0.001$).

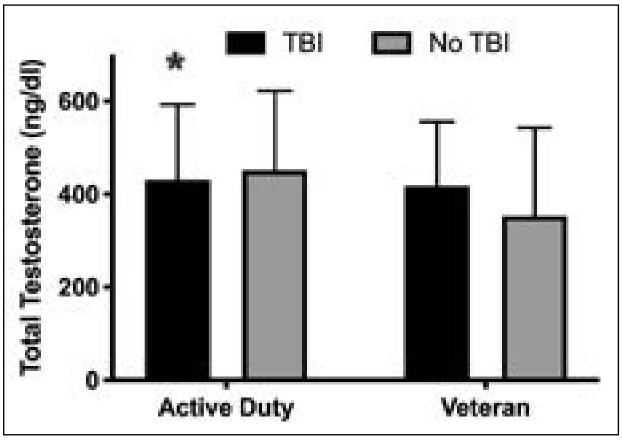

Figure 1. Testosterone concentrations in active duty and veteran men with and without TBI. Data are presented as means ± standard deviation. ****P* **< 0.05 significantly lower than active duty males without TBI.**

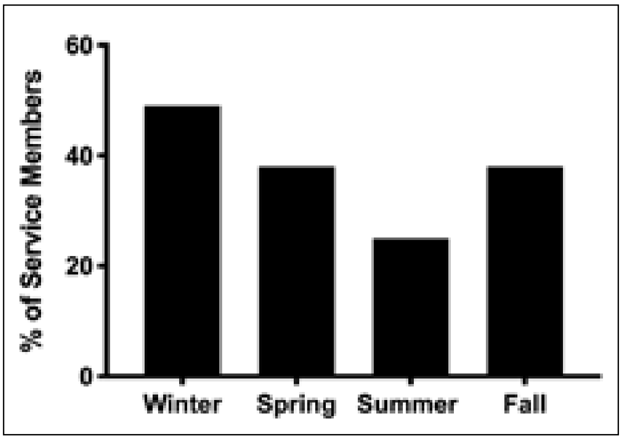

Figure 2. Percentage of Service Members Insufficient in Vitamin D (<30 ng/ml) Across Each Season (in the US): Winter (December, January, February), Spring (March, April May), Summer (June, July, August), Autumn (September, October, November).

Vitamin D concentrations in service members

Overall, mean vitamin D concentrations were 35 ± 12 ng/ml (range 8–60 ng/ml) for men and 32 ± 12 ng/ml (range 9–60 ng/ml) for women. Thirty-eight per cent of all service members assessed were insufficient in vitamin D (< 30 ng/ml; 36% of men, 46% of women). One hundred and fifty-four service members (9%) were deficient in vitamin D (< 20 ng/ml). Active duty service members had higher concentrations of vitamin D compared to veterans (35 ± 12 vs 33 ± 12 ng/ml, $t = -3$, $P = < 0.01$). Men had higher vitamin D concentrations compared to women (35 ± 12 vs 32 ± 12 ng/ml, $t = -4$, $P = < 0.001$). Active duty men had higher vitamin D concentrations than active duty women, and veteran men had higher concentrations of vitamin D than veteran women (Table 1). There were no significant differences in vitamin D concentrations between active duty and veteran men or between active duty and veteran women. Veteran women were significantly more likely to have vitamin D insufficiency than veteran men, although there was no difference between active duty men and active duty women. The seasonal vitamin D assay was evenly distributed—assessments were 24% in the spring, 23% summer, 29% autumn and 24% winter. Vitamin D concentrations were significantly different across seasons, hitting a nadir in winter and peak in summer ($F(3, 1738) = 26$, $P < 0.001$; Figure 2). Vitamin D concentrations in winter (32 ± 11 ng/ml) were significantly lower than spring (35 ± 12 ng/ml), summer (38 ± 12 ng/ml) and autumn

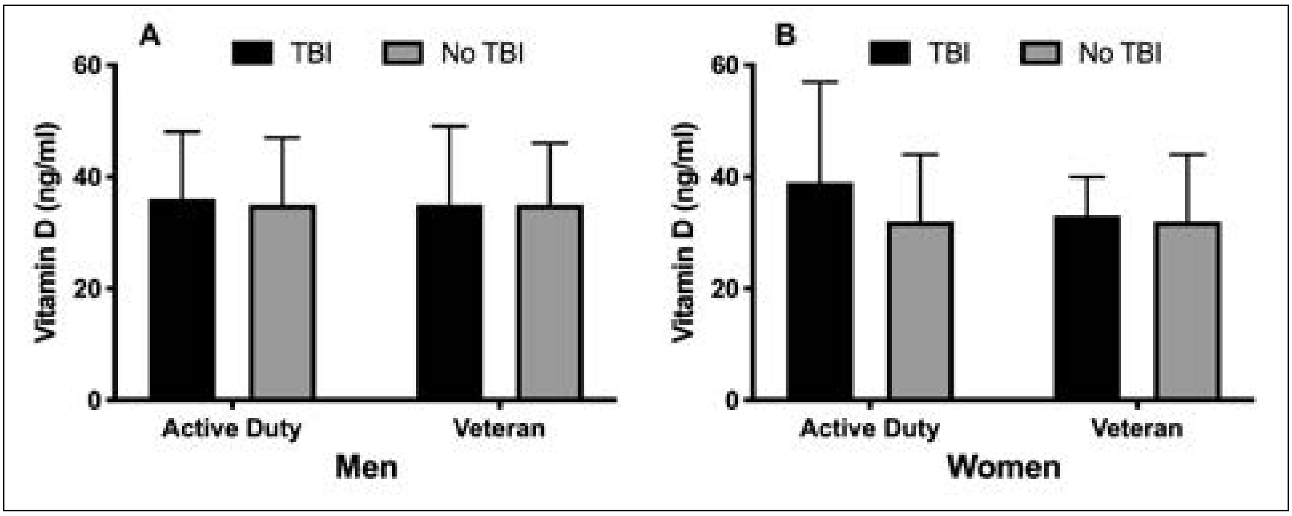

Figure 3. Vitamin D concentrations in active duty and veteran men (A) and women (B) with and without TBI. Data are presented as means ± standard deviation. There were no significant differences between groups.

(34 ± 11 ng/ml, *P* < 0.001). Summer vitamin D concentrations were higher than in the spring and autumn, but there were no significant differences between autumn and spring.

Contrary to our hypothesis, service members with a history of TBI had significantly higher concentrations of vitamin D compared to service members without a TBI (36 ± 12 vs 34 ± 12 ng/ml, t = –2, *P* = 0.034), but the difference was minimal (2 ng/ml) and of little clinical significance. There was no significant difference in service members with and without TBI for vitamin D insufficiency (34 vs 38%, χ^2 (1, n = 1742) = 1, *P* = 0.26). Vitamin D concentrations were not different between active duty or veteran service members with or without TBI history (Figure 3).

Correlations between testosterone and vitamin D concentrations in service members

Overall, there was a weak positive correlation between testosterone and vitamin D concentrations for men (r = 0.099, *P* < 0.001) but not for women (r = 0.004, *P* = 0.94). This significant correlation was maintained when compared among active duty men (r = 0.087, *P* = 0.005) and veteran men (r = 0.12, *P* = 0.028). When men were analysed separately by testosterone prescription, there was still a positive correlation between vitamin D and testosterone concentrations for men without testosterone prescriptions (r = 0.095, *P* = 0.003). No significant correlations were found in active duty or veteran women.

There was a weak positive but significant correlation between testosterone and vitamin D concentrations (r = 0.099, *P* < 0.001) for men without a TBI compared to men with a TBI (r = 0.11, *P* = 0.12) Likewise, active duty men without a TBI demonstrated a weak but significant positive correlation between testosterone and vitamin D concentrations (r = 0.081, *P* = 0.018), while active duty men with a history of TBI had no significant correlation (r = 0.13, *P* = 0.076). No significant correlations were found in active duty or veteran women with a TBI.

Discussion

Traumatic brain injury has been shown to cause low testosterone concentrations due to pituitary dysfunction and may affect vitamin D status, but no published research to date has investigated both of these hormones in military personnel with TBI. In this retrospective analysis, we did not find higher rates of pituitary dysfunction (low testosterone) or vitamin D deficiency in military personnel with a TBI history compared to military personnel without prior injury. In our dataset, active duty men with a TBI had statistically lower testosterone than active duty men without prior injury, but the difference was small and of little clinical significance. No clinically meaningful relationship was observed between TBI and vitamin D deficiency. However, our overall dataset showed a high prevalence of vitamin D insufficiency in active duty and retired service members independent of TBI. Correlations between testosterone and vitamin D concentrations were positive but weak in men. Perhaps these findings are driven by a low medically reported TBI diagnosis. Eight per cent of military personnel in our sample had a TBI diagnosis, which is lower than previous research showing 11–23% of military personnel had been diagnosed with a TBI.[21] Our overall findings in military personnel do not support high prevalence of hypogonadism in men with a history of TBI.

Previous research has found pituitary dysfunction in 31–48% of male service members after TBI, although not exclusive to hypogonadism.[2,16-18] In our sample, 15% of men had low testosterone, which is comparable to other reported findings of hypogonadism in service members ranging from 0–19%.[2,16-18] Contrary to military studies, civilian studies investigating pituitary dysfunction after TBI have shown higher hypogonadism rates among participants, ranging from 1.4–80%.[14] These findings suggest that blast-induced TBI may affect pituitary function differently from non-blast-induced TBI, resulting in lower hypogonadism rates.[16,17] Time post-injury and clinical cut-offs for testosterone deficiency also varied between both military and civilian studies.[14,18] Nearly all military studies used the 5th or 10th percentile of the sampled group to determine hormone deficiency (199–330 ng/dl).[2,16-18] We analysed our data using the Army Medical Department cut-off of 270 ng/dl and the American Association of Clinical Endocrinologists[22] and Endocrine Society Clinical Practice Guidelines[23] cut-off of <300 ng/dl without significant differences in results. Our results could have been influenced by the time between injury and the testosterone assessment, as we did not have data for this analysis. Gonadotropin function has been shown to spontaneously resolve at 3 to 12 months after injury in a majority of patients due to temporary pituitary dysfunction from hypothalamic-pituitary oedema, increased intracranial pressure and the physiologic response to either critical illness or drugs used in the acute phase of TBI.[1,4,5,24] Our military personnel with TBI may have had testosterone deficiency but recovered prior to testosterone assessment and treatment, which may explain our low rates of hypogonadism. In addition, a negative correlation between testosterone concentrations and injury severity may exist in the immediate post-TBI period.[24] Perhaps more significant correlations would be evident in severe cases. [24] To our knowledge, this is the first study investigating testosterone prescription after TBI. We found no association between testosterone prescriptions and TBI diagnosis, which would coincide with the low rates of hypogonadism, thus warranting fewer prescriptions. Military treatment facilities have also become more conservative with prescribing testosterone replacement therapy.[25]

Inadequate sleep, energy deficits and physical stress during deployment and Special Operations Forces training have been shown to suppress testosterone levels in military personnel.[26] This finding may explain why active duty men with TBI had lower testosterone concentrations than active duty men without injury, while veterans with TBI did not have this result. Testosterone production may be reduced post-TBI due to inflammatory cascade cytokines suppressing Leydig cell function in the testes, leading to hypothalamic-pituitary-gonadal axis dysfunction.[27] Veterans with a TBI had higher testosterone than veterans without a TBI, but several veteran men without a TBI in our analysis had very low testosterone (<10 ng/dl). This result is drastically lower than the age-related decline NHANES data has shown with participant's testosterone concentration at age 80 being 30% less than at age 20.[28] Interestingly, none of these testosterone deficient veterans were prescribed testosterone replacement therapy; assuming they did not show symptoms of androgen deficiency. This finding would be normal according to the Endocrine Society recommendations.[23] Another explanation for this finding could be influenced by the unknown length of time after injury since anterior pituitary trauma may result in normal or high serum concentrations of testosterone from the acute release of stored hormones after injury.[24]

Our findings on vitamin D concentrations support previous research in civilians and military personnel, showing that low vitamin D is a common ailment independent of TBI.[6,29] To our knowledge, this is the first study examining both testosterone and vitamin D concentrations in military personnel with and without TBI. Previous studies of civilians after TBI found similar vitamin D deficiency rates compared to our results (24–47% vs 34%).[10,12,13] However, the cut- off rates for these studies were lower than ours with < 10, 14 and 16 ng/ml being deficient.[10,12,13] Two studies with an equivalent cut-off found much higher rates of insufficiency at 63–95%.[9,11] Rates of deficiency/insufficiency are influenced by differences in latitude, clothing, race and diet of the different countries in which these studies were conducted. The 35.1°N latitude of Fort Bragg allows for an extended period of endogenous vitamin D synthesis that would explain our lower rate of vitamin D insufficiency versus other studies.[19] We did not have adequate racial data to include in the analysis.

Studies have shown mixed results between vitamin D concentrations and TBI severity. Jamall et al.[12] found no difference in vitamin D among TBI severities, while Toman et al.[13] found patients with severe TBI were the most deficient in vitamin D. Separate analysis of the most severe TBI cases may have shown a higher prevalence of vitamin D deficiency. However, we did not have severity data for all cases. In this study, the seasonal distribution of vitamin D assessments was fairly evenly distributed throughout the year. In the US, vitamin D seasonality peaks in August and nadirs in February; and during winter months ultraviolet radiation for most US latitudes north of Atlanta, GA (33.7°N) is inadequate for sufficient endogenous synthesis of vitamin D.[6]

Our weak but positive correlation between vitamin D and testosterone in servicemen is consistent with previous findings by Wentz et al.[19], who found a stronger correlation in vitamin D deficient men. Contrary to these findings, one study found an increase in testosterone concentrations in active duty males during basic military training despite a significant decrease in vitamin D.[29] The intense training and anabolic adaptations that occur during basic military training plus the younger age of soldiers who participate in bootcamp may explain the different correlations between vitamin D and testosterone. Vitamin D may be positively correlated with testosterone concentrations in men due to the expression of the vitamin D receptor and metabolising enzymes in the Leydig cells of the testes and has been shown to raise testosterone levels in vitamin D deficient men.[20] No correlation was found between vitamin D and testosterone in men with TBI, possibly due to a smaller sample size given that no difference was discovered in vitamin D between men with and without injury.

We did not find evidence that TBI causes low vitamin D, but other research suggests that low vitamin D may exacerbate injury. Vitamin D may promote resilience after TBI by regulating calcium ions, oxidative stress, inflammation and apoptosis during the secondary cascade of injury.[7,9] Cui et al.[7] found that calcitriol treatment can improve neurobehavioral defects and cerebral oedema in rats after TBI. In human trials, one study found patients with vitamin D deficiency on admission to the neurological critical care unit had worse three-month Glasgow Outcome Scores than vitamin D sufficient patients. Another study found vitamin D supplementation increased long-term performance and cognitive outcomes in vitamin D deficient patients with mild to moderate TBI.[8,9]

Our overall dataset shows a high prevalence of vitamin D insufficiency. Since military personnel are at high risk for TBI and tactical gear limits adequate sunlight exposure, it is recommended to assess vitamin D status biannually.[30] It would be beneficial to supplement those with insufficiency and deficiency accordingly to Endocrine Society Guidelines to maintain optimal vitamin D levels as a preventive measure to improve resiliency post-TBI.[31] Since gonadotroph function may spontaneously recover in 3 to 12 months after injury, endocrine evaluation should be completed at 3 to 6 months and re-assessed at 12 months post-TBI.[5] Studies have shown testosterone replacement therapy to increase lean body mass and strength while reversing cachexia in diseased populations and readily reverse symptoms of neuroendocrine dysfunction once identified.[26]

This study was strengthened by a large set of medical records reviewed for one geographical location, which limited the effect of latitude. This study's limitations include the medical record review's observational nature in which causal relationships cannot be established, only correlations. Furthermore, data for confounding variables such as race, sex hormone binding globulin, training status, dietary supplements, testosterone prescriptions prescribed by providers outside of the DoD medical system, length of time after injury, and body mass composition were not available for analysis. Lastly, this sample consists of military personnel who had testosterone and vitamin D ordered by a physician and is not representative of all service members.

Our research does not support evidence for high rates of hypogonadism, testosterone prescription or vitamin D deficiency after TBI compared to military personnel without prior injury. However, we show a high prevalence of vitamin D insufficiency in active duty and retired service members independent of TBI, further supporting that vitamin D status should be assessed regularly in service members. A prospective analysis pre-injury may provide better insight into the role of testosterone and vitamin D in TBI.

Disclaimer

The views expressed herein are those of the authors and do not reflect the official policy of the Department of the Army, Defense Health Agency, Department of Defense or the US Government.

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Health Promotion in the Australian Defence Force

N Westphalen

Introduction

This article follows previous papers by the author regarding occupational and environmental medicine in the ADF.[1,2,3,4,5,6,7,8]

These articles, as well as a recent Productivity Commission inquiry,[9] indicate that high workplace illness and injury rates confirm the need to improve the management of hazards associated with ADF workplaces, with better emphasis on prevention. To this end, a submission by the Royal Australasian College of Physicians to the aforementioned inquiry advocated this would best be achieved by basing the ADF's health services on a systems-based occupational health strategic model.[10]

Doing so would require reassessing the fundamental inputs to capability[11] for both Joint Health Command (JHC) and Defence's Work Health and Safety Branch. The current state of the ADF's occupational and environmental health services, and the small number of civilian specialist practitioners within the Australasian Faculty of Occupational and Environmental Medicine (AFOEM), suggest that a mature holistic and sustainable model would take 10–15 years' sustained effort.

This article expands on these papers, with respect to the provision of military health promotion activities for ADF members.

Military health promotion

The World Health Organisation (WHO) defines health promotion as 'the process of enabling people to increase control over, and to improve, their health. It moves beyond a focus on individual behaviour towards a wide range of social and environmental interventions'.[12]

While acknowledging the importance and relevance of this definition, the importance of military health promotion as an operational capability enabler also warrants consideration. One of the more egregious historical examples where this did not occur would be Rear Admiral Francis Hosier's operations in the West Indies in 1726–29: he, both his successors in command and 4000 men all succumbed to yellow fever while blockading Portobello in modern Panama, out of a force that never exceeded 3300 at any one time, without a shot being fired.[13]

Commodore George Anson's 1740–44 world circumnavigation did only marginally better. Having left the UK with 1967 men, he returned having lost 1240 (63%), of whom only four were killed in action. The rest died through being medically unsuitable for deployment in the first place, as well as by heat and cold exposure, malaria, dysentery, typhus and scurvy.[14]

Somewhat more recently, General William Slim wrote of the 1941–45 Burma campaign:

> *'In 1943, for every man evacuated with wounds we had one hundred and twenty evacuated sick. The annual malaria rate alone was eighty-four per cent per annum of the total strength of the army, and still higher among the forward troops. Next to malaria came a high incidence of dysentery, followed in this gruesome order of precedence by skin diseases and a mounting toll of mite or jungle typhus, a peculiarly fatal disease. At this time, the sick rate of men evacuated from their units rose to over twelve per thousand per day. A simple calculation showed me that in a matter of months at this rate my army would have melted away. Indeed, it was doing so under my eyes'.*[15]

Closer to Australia, General Douglas Macarthur said to his staff medical officer in May 1943:

> *'Doctor, this will be a long war if for every division I have facing the enemy, I must count on a second division in hospital with malaria, and a third division convalescing from this debilitating disease!'*[16]

Even so, it has been suggested that the Western Allies' health promotion efforts in both World Wars gave them a significant operational edge over their opponents.[17,18] Furthermore, the ability to prosecute the subsequent conflicts in southeast and southwest Asia certainly would not have been possible without effective military health promotion.[19]

Yet, infectious disease can still significantly impede military operational capability.[20,21] For example, a survey by Hyams et al. of 2022 US military personnel during the 1990–91 Gulf War indicated that, after an average of two months in Saudi Arabia, 57% had at least one episode of diarrhoea, with nearly a third reporting they were temporarily unable to carry out their duties.[22] Closer to Australia, 267 of the 5500 ADF personnel who had served up to six months in East Timor in 1999–2000 (4.8%), presented with malaria six months after their return.[23] Overall, the ADF recorded 359 such cases in 2000, with 306 from East Timor, and another 32 from Bougainville and Papua New Guinea.[24]

Current ADF health promotion

These examples highlight military health promotion activities as a key operational enabler: not only by conserving labour via reducing the demand for treatment and evacuation services by minimising disease risk, but also by optimising each member's health in order to give them a capability edge over their opponents. Both benefits are essential for small forces such as the ADF.

Military health promotion activities include targeted vaccination programs, effective field and shipboard hygiene, and vector-borne infectious disease prevention. To these can be added health education activities such as first aid, personal hygiene and dental care, heat and cold stress management, sunburn and insect bite prevention, alcohol and other drug awareness, and diet and weight control. Particular attention should also be given to enhancing physical resilience and mental health.

The effectiveness of such measures can be illustrated by the response to the aforementioned ADF malaria rates in East Timor, Bougainville and Papua New Guinea: the total number of new cases was reduced to 31 in 2001,[25,26] and 27 in 2002.[27,28]

Royal Australian College of General Practitioner's 'Red Book'[29]

Current JHC guidance for the conduct of primary care health promotion is based on the *Guidelines for preventive activities in general practice*—the 'Red Book'. Its remit is to cover 'primary' (preventing the initial occurrence of a disorder) and 'secondary' (preventive early detection and intervention) activities.

Review of the 'Red Book' demonstrates a comprehensive range of preventive medicine activities, including:

- preventive activities prior to pregnancy
- genetic counselling and testing
- preventive activities in children and young people
- preventive activities in middle age
- preventive activities in older age
- communicable diseases
- prevention of chronic disease
- prevention of vascular and metabolic disease
- early detection of cancers
- psychosocial.

However, the 'Red Book' also specifically states that its preventive activities are geared to the Australian general practice population, rather than specific subgroups such as Indigenous Australians or LGBTQI communities. Furthermore, the 'Red Book' does not include detailed information regarding the management of specific health risk factors, while the scope of its guidance regarding infectious disease prevention is limited to those typically only seen in Australia.[30]

Regarding the latter, the 'Red Book' has only limited travel medicine advice, instead referring to the United States' Centers for Disease Control and Prevention, and the WHO International Travel and Health websites.[31,32] Both are already used (among others) for ADF operational health planning purposes.

As the 'Red Book' is not designed or targeted for a working age group of mainly young employees who are liable to deploy to locations where they will encounter health threats unlikely to be found in the general Australian population, this paper contends that the ADF constitutes its own subgroup, comparable to the aforementioned Indigenous and LGBTQI communities. As such, the 'Red Book' only constitutes a baseline for further military-specific health promotion activities.

Furthermore, without decrying their importance for the health and wellbeing of ex-ADF members as they age, the role of military health promotion as an operational enabler implies that 'Red Book' healthy lifestyle interventions related to (among others) smoking cessation, treatment of hypertension and/or weight control, should not of themselves prevent them from deploying, if such activities are elective in nature and/or do not prevent them from performing their regular duties.

This assertion reflects the extent to which the effects of unnecessarily preventing ADF members from deploying must not be underestimated. Besides compromising operational capability in the immediate term (for example regarding 'ship-stopper' crew members), it also impedes medium-and longer-term operational capability by delaying their career progression, which may result in eminently avoidable retention issues. To these may be added unintended consequences regarding future patient compliance and willingness to present to ADF health staff, as well as perception management issues, not only regarding individual health staff members who may be perceived as needlessly blocking their career aspirations, but also the ADF's health services in general.

ADF health assessments

ADF periodic health assessments are presently conducted every five years until age 40, with progressively shorter intervals thereafter.[33] At present, these timeframes do not reflect personnel or occupational health legislative considerations, but resourcing issues based on the health promotion guidance per the 'Red Book'. From an occupational and environmental health perspective, using this guidance for a highly medically selected, young and generally fit ADF population is unduly conservative—evidence suggests they can be performed five-yearly until age 60.[34]

Furthermore, the ADF health assessment's scope needs to be far broader than the 'Red Book' healthy lifestyle checks. The author has previously explained why such examinations do not preclude the requirement for additional targeted periodic and other health assessments (followed by the relevant health promotion activities) in order to:

- align with the non-deployment-related legislative requirements of the *Work Health and Safety Act* 2011 and its implementing regulations, as well as Safework Australia's supporting guides, National Standards and Model Codes of Practice.[35,36,37] Review of the Defence Health Manual has confirmed the extent to which the ADF's current policy guidance with these standards is reactive and incomplete.[38]
- confirm health status prior to deployment (including sea postings for Navy and other ADF personnel), with respect to their medical employment standard and deployment-specific vaccinations and other preparations, and 're-baselining' their medical status for subsequent compensation purposes.[39]

Musculoskeletal injuries

A key consideration regarding health promotion activities to enhance physical resilience is that they should not exacerbate old injuries, or cause new ones.

The author has previously noted that, anecdotally, perhaps 30–40% of ADF primary care presentations pertain to musculoskeletal (MSK) injuries, of which about half are work-related slips, trips and falls, while the remainder are sports-related.[40,41] In support of this assertion, the ADF's Health Surveillance System (EpiTrack) showed that in 2007–08 and 2008–09, the most common medical conditions were injuries and MSK disorders. These were also the most common conditions resulting in sick leave.[42]

The relevance of effective health promotion for preventing compensable MSK injuries should not be underestimated. For example, a 2009 study of DVA compensation claims for chondromalacia patellae (CMP), indicated that the incidence of this overuse injury alone within Navy was 0.33% per year, most of which developed in the first years of service.[43] If CMP is one of the five most common MSK disorders in Navy, and if the incidence rates of these conditions are comparable, 1.65% of its workforce (231 new cases, or more than one *Hobart* DDG crew) will sustain compensatable yet eminently preventable MSK injuries every year.

Furthermore, Table 1 lists the 15 most frequently claimed conditions under the *Veteran's Entitlements Act* 1986 (VEA) in 2014–15. These make up 61.5% of all conditions claimed under the VEA from current and ex-serving members, based on the Statements of Principles of the Department of Veterans Affairs' Repatriation Medical Authority. Table 1 suggests that 20.5% of these claims were for MSK conditions.[44]

Table 2 lists the 15 most frequently claimed conditions under the Safety, *Rehabilitation and Compensation Act* 1988 (SRCA) in 2014–15, which make up 85% of all conditions claimed under the SRCA from current and ex-serving members. Table 2 suggests that about 63.7 of all SRCA claims were for MSK conditions.

Table 3 lists the 15 most frequently claimed conditions under the Military Rehabilitation and Compensation Act 2004 (MSRCA) in 2014–15, which make up 56.5% of all conditions claimed under the MRCA from current and ex-serving members. Table 3 indicates that at least 33.9% of all SRCA claims were for MSK conditions.

Table 1: 15 most frequently claimed conditions (based on VEA Statements of Principles) in 2014–15[45]

Disability	Claims accepted	Acceptance rate	Claims rejected	Total claims
Osteoarthritis	1,623	76%	514	2,137
Sensorineural hearing loss	1,372	99%	14	1,386
Tinnitus	1,307	98%	26	1,333
Lumbar spondylosis	930	84%	181	1,111
Solar keratosis	640	99%	9	649
Posttraumatic stress disorder	472	76%	151	623
Non-melanotic skin cancer	533	99%	7	540
Depressive disorder	270	56%	211	481
Alcohol use disorder	218	55%	176	394
Hypertension	100	31%	219	319
Cervical spondylosis	82	28%	211	293
Ischaemic heart disease	154	53%	139	293
Acquired cataract	223	100%	1	224
Rotator cuff syndrome	70	32%	150	220
Chronic bronchitis	124	60%	84	208
Totals	**8,118**	**79%**	**2,093**	**10,211**

Table 2: 15 most frequently claimed conditions under the SRCA in 2014–15[46]

Disability	Claims accepted	Acceptance rate	Claims rejected	Total claims
Sprains and strains of joints and adjacent muscles	552	66%	279	831
Deafness	128	48%	141	269
Mental disorders	78	39%	120	198
Other and unspecified injuries	90	67%	45	135
Disorders of muscle, tendons and other soft tissues	92	74%	32	124
Other diseases	36	39%	56	92
Superficial injury	21	29%	52	73
Fractures	45	66%	23	68
Arthropathies and related disorders—disorders of the joints	35	65%	19	54
Dorsopathies—disorders of the spinal vertebrae and intervertebral discs	36	69%	16	52
Other diseases of skin and subcutaneous tissue	24	51%	23	47
Other disorders of the eye	19	46%	22	41
Osteopathies, chondropathies and acquired musculoskeletal deformities	26	72%	10	36
Other malignant neoplasms and carcinomas	7	21%	26	33
Other diseases of the ear and mastoid process	10	33%	20	30
Totals	**1199**	**58%**	**884**	**2083**

Table 3: Top 15 statements of principles used in MRCA decision making in 2014–15[47]

Disability	Claims accepted	Acceptance rate	Claims rejected	Total claims
Sprain and strain	1514	90%	176	**1690**
Osteoarthritis	732	82%	161	**893**
Tinnitus	710	96%	27	**737**
Depressive disorder	518	74%	184	**702**
Fracture	591	86%	94	**685**
Lumbar spondylosis	567	87%	87	**654**
Sensorineural hearing loss	556	90%	64	**620**
Rotator cuff syndrome	509	89%	60	**569**
Post traumatic stress disorder	460	88%	65	**525**
Joint instability	300	88%	42	**342**
labral tear	289	88%	39	**328**
Chondromalacia patellae	281	89%	34	**315**
Intervertebral disc prolapse	260	88%	35	**295**
Shin splints	286	98%	6	**292**
Acute meniscal tear of the knee	230	89%	27	**257**
Totals	**7803**	**88%**	**1101**	**8904**

In short, these tables indicate the extent to which the ADF's current physical fitness programs are in fact impeding operational capability by exacerbating old MSK injuries and creating new ones. Furthermore, the fact that only 11–19% of Army Reserve and Regular work-related injuries and illnesses are currently being reported on the Defence Work Health and Safety Compensation and Reporting (WHSCAR) System ('Sentinel'),[48] indicates that the number of work-related MSK injuries across all three services is grossly underestimated. Hence too many MSK injuries are considered 'business as usual' rather than eminently preventable through interventions including effective health promotion.

Mental health conditions

Tables 1–3 indicates that in 2014–15, at least 3.7% of VEA claims, 5.5% of SRCA claims and 7.1% of MRCA claims were for mental health (MH) conditions. High rates in the civilian community, and their usually self-limited nature, are consistent with the author's previous assertion that perhaps 30–40% of ADF clinical presentations are for generally preventable MH issues. Anecdotally, perhaps half of these members lack psychological robustness for whom the ADF has been a poor career choice; the remainder tend to be members who are psychologically robust but are not coping with excessively demanding or otherwise dysfunctional ADF workplaces or personnel management practices.[49]

It should be noted, while up to 22% of ADF members may have a diagnosable MH disorder, their deployment status did not have an impact, despite the grossly traumatic circumstances associated with some deployments.[50,51] This confirms the need for military MH promotion programs to enhance normal workplace and personnel management practices in the base setting as well as while deployed. To this end, the Royal College of Physicians *Health Benefits of Good Work* offers some useful guidance. The key theme is how healthy workplaces—including MH—are a leadership, management and supervisor (i.e. not simply a health) responsibility.[52]

Conclusion

With ADF personnel arguably exposed to the most diverse range of occupational and environmental hazards of any Australian workforce, high rates of preventable workplace illness and injury indicate the need to improve the management of occupational and environmental health hazards with more emphasis on prevention than treatment.

Although it provides extensive preventive health guidance, the 'Red Book' only provides a baseline for additional military-specific health promotion activities. Rather than the current reactive and ad hoc approach (especially regarding non-deployed workplaces), there is a need for a far more systematic application of:

- compliance with the *Work Health and Safety Act* 2011 and its implementing regulations, as well as Safework Australia's supporting guides, National Standards and Model Codes of Practice
- better targeted military- and mission-specific vaccination programs, effective field and shipboard hygiene, and vector-borne infectious disease prevention.
- military health education programs on topics such as (but not limited to) first aid, personal hygiene and dental care, heat and cold stress management, sunburn and insect bite prevention, alcohol and other drug awareness, and diet and weight control. A key consideration is that healthy lifestyle interventions should not prevent personnel from deploying if they are elective in nature and/or do not prevent them from performing their normal duties.
- military workplace physical fitness programs that do not of themselves exacerbate old injuries or cause new ones
- military workplace MH promotion programs that, besides enhancing mental resilience during deployments, generally enhance typical workplace and personnel management practices in the base setting as part of the broader guidance per the *Health Benefits of Good Work*.

It should also be noted, military health promotion programs are additional to, and not a substitute for, ensuring that ADF workplaces are healthy and safe in the first instance.

These considerations further support the contention that the ADF's health services should be premised on an occupational-health-based systems model, with revised fundamental inputs to capability that would lead to a range of genuinely holistic, sustainable and fit-for-purpose health services over the next 10–15 years.

Author

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Commander Westphalen transferred to the Active Reserve in 2016. Comments regarding this and previous articles are most welcome.

Disclaimer

The views expressed in this article are the author's and do not necessarily reflect those of the RAN, or any of the other organisations mentioned.

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Disclaimer: the author was requested to draft this submission, as a member of the AFOEM Policy and Advocacy Committee (PAC). It was cleared by both the Faculty and College PACs prior to submission.

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Personnel;

Organisation;

Collective training;

Facilities;

Supplies;

Major systems;

Support, and

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"If You're Happy and You Know It Raise Your Hand (and Answer the Question)" Learner Centered Strategies for Teaching Army Junior Health Officers on the Pilot Health Officer Basic Course.

L Daly

Introduction

The Australian Army employs a range of specialist service officers (SSOs) and general service officers at junior level (Lieutenant or Captain) across four health corps and 12 trades. Currently, new Junior Health Officers (JHOs) are required to undertake a range of health and logistics training courses in addition to all-corps training.

During the past 10 years, five reviews have recommended substantial changes to Army JHO training.[1-5] Key findings included a current lack of an identifiable and streamlined package for all health trades, absence of an introductory Special to Profession course and out-dated curricula. It was also identified that Psychology Officers were not included in any JHO courses provided by the Army School of Logistics Operations. As a result, the Army School of Logistics Operations tasked the Army School of Health to develop a stand-alone Health Officer Basic Course (HOBC) to provide skills and knowledge required by JHOs commencing their health support duties in Army.

The pilot HOBC provided the Army School of Health an opportunity to design and trial an enhanced learning experience addressing the previous reviews key themes. An integral part of this process was to evaluate whether the curriculum met the requirements of JHO's with different skillsets, experience levels and corps backgrounds.

While the actual course subjects are not discussed extensively in this paper, the subjects delivered intended to provide the assumed skills and knowledge of the JHOs commencing their new role, but not yet taught in one streamlined curriculum. The course, held over two weeks, was designed from scratch with no formal learning management package, including timetables, lesson content, trainee handbook and practical activities.

This article aims to provide a brief overview of the course delivery and the educational methods applied to the design.

Panel diversity and content design

Sixteen trainees attended the course. The original panel was three Royal Australian Army Medical Corps General Service Officers who had recently graduated from the Royal Military College Duntroon. In order to obtain constructive input as to the pre-existing level of knowledge and experience among JHOs, while enabling constructive evaluation, 13 additional JHOs with varying degrees of experience and skills were selected to attend (Table 1). It was considered that these extra participants would also provide a collaborative and interactive learning environment for the three new Duntroon graduates. It is noted that the mixture of skillsets and experiences resulted in difficulty in establishing a clear level of 'assumed knowledge' for the course and this was provided as part of the feedback for future panel design.

The course design was not done in isolation, with a number of key stakeholders sent the drafted curriculum for feedback including Directorate of Army Health, Joint Health Command and Royal

Table 1 - Overview of trainees attending the pilot HOBC

RANK	CORPS	STREAM	COMPLETED LOBC	COMMENTS
LT	Royal Australian Army Medical Corps	GSO	2019	
LT	Royal Australian Army Medical Corps	GSO	2018	
LT	Royal Australian Army Medical Corps	GSO	2018	
LT	Royal Australian Army Medical Corps	GSO	2019 - Army Reserve component only	Gap year Lieutenant
LT	Royal Australian Army Medical Corps	GSO	2019 - Army Reserve component only	Gap year Lieutenant. Is a civilian Paramedic.
LT	Royal Australian Army Medical Corps	GSO	2017	
LT	Royal Australian Army Medical Corps	GSO	2019	Was previously an Army medic and commissioned in 2018.
LT	Royal Australian Army Medical Corps	GSO	2019	Corps transferred from Cavalry end of 2018. Completed first year of Bachelor of Nursing.
CAPT	Australian Army Intelligence Corps	GSO	N/A - Corps transfer from Australian Army Intelligence Corps.	Corps transfer from Australian Army Intelligence Corps. Completed Regimental time in Royal Australian Artillery corps.
LT	Royal Australian Army Medical Corps	GSO	2019	
LT	Royal Australian Army Medical Corps	GSO	2019	

Military College, Australia. A Likert-scale self-assessment was sent to each trainee six weeks out from the commencement of the course, which provided the Officer in Charge an opportunity to identify consistent gaps in knowledge for the trainees.

Results were utilised to adjust the timetable, where possible, to dedicate additional time on the subjects that the majority of the course had indicated they had limited knowledge on (Table 2).

Training transformation

The increasing emphasis on training transformation within the Australian Defence Force (ADF) has required leaders to adapt and react to different learning methods. As highlighted in The Ryan Review, Army training continuums should consider the balance of command and influence for developing leaders.[2] This includes the exploration of alternative learning models for leadership development if necessary. The design of the HOBC focused on intertwining the development of leadership ability and the knowledge and adaptability required to perform their roles.

The nature of a JHO role (often regardless of trade), is having to inform, educate and lead non-health commanders in often austere or complex environments and situations. Learning is a social and collective process whereby knowledge is co-constructed.[3] This was considered during the design by incorporating aspects of Albert Bandura's theory of social learning.

Social learning theory

Bandura's theory encourages learning in a more social and informal setting than traditional education environments. The opportunity to trial new and innovative training delivery methods was afforded as part of this pilot course. As such, design consideration for the HOBC included creating an interactive learning experience. This was achieved through the creation of theory lessons linked to practical demonstrations and activities. Further consideration applied was the suitability of instructors (emphasising current experiences) and incorporating several informal and formal networking events.

Attention and interaction

To learn from observation, individuals must first attend to the important components of the behaviour that is being modelled. If a lesson or task is seen as being novel or different somehow, the likelihood of it being focused on is higher. A challenge when applying this variable to the HOBC was that the panel comprised JHOs with different experiences and expectations.

An adult learning environment was established early on with the introductory brief from the Commanding Officer to keep the course panel engaged. Trainees were briefed on how valuable their input to the possible establishment of a formal HOBC would be and identified that the non-assessed course was designed to be engaging, positive and meaningful. Emphasis was given to challenging and promoting self-directed learning for each participant to bridge at least one self-assessed gap in knowledge provided from their initial self-assessment.

Table 2 - Trainee responses for Likert-scale self assessment. The above scope of learning were not exhaustive and the curriculum included additional topics.

Scope of learning/experience	No exposure	Taught but not yet applied the knowledge	Require more training and education	Requires support from a qualified member to complete	Fairly confident but have some questions	Very confident	Complete regularly as part of my role
Understanding of MT training continuum – e.g. *Do you know what courses MTs undertake, their roles in a unit, promotion/ career progression reqs?*	3	1	2	2	3	1	2
Understanding of NO training continuum – e.g. *Do you know about entry methods to Army for NOs, what roles they can fill in units, career progression reqs?*	2	3	2	2	2	1	
Understanding of MO training continuum – e.g. *Do you have an understanding of the various medical levels for MOs, progression through ML1 – ML 4 and what their roles are at each level?*	2	3	2	4	1	1	1
Mental health support – e.g. *Do you have an understanding on CIMHS, how to write a PM008, what external mental health support services you could recommend to your soldiers?*	1	2	3		6		2
Credentialing/OPNOMS/Waivers – e.g. *Are you aware of the various requirements to credential a clinician, the nomination process of deployments and how to apply for a waiver for courses/ exercises/operations?*	3	1	2	2	3	1	2
MEC status/MECRB/IWB/UWB – e.g. *Do you have an understanding of the different MEC status', when/why a MECRB is initiated, the purpose of an IWB/UWB and how to create an action plan?*		1		3	7		3
Casualty Regulation Cell – e.g. *Do you have an understanding of the various roles within a CRC, how to action an AME, who commands a CRC?*	2	2	1	2	6	1	
Clinical incidents – e.g. *Do you have an understanding of what entails a clinical incident, the reporting process and Severity Assessment Codes?*	4	2	2	2	6		
DACC/CONFE – e.g. *Do you have an understanding of the various contingency forces for health, what DACC is and the levels that it is enacted at?*	4	5	3	3	1		
RBG/RCT – e.g. *Do you have an understanding of the RBG/RCT orbat, likely tasks and actions on it being enacted.*	4	4	3	3	2		
Health Support Plans – e.g. *Do you have an understanding of how to write an effective HSP for a Coy sized activity?*	4	3	4	1	3	1	
SCA management – e.g. *Do you have an understanding on management of clinical equipment including technical inspections, consumables and medications?*	4	2	2	4	2	1	1
PCNB writing – e.g. *Do you have experience in writing PCNBs, the PAC process and incorporation of technical reports into soldier reports?*	5	4	2		2	2	1

So what, therefore?

Lessons were designed to focus on the 'so what, therefore' of why the content was necessary for a JHO to know and understand. Instructors were selected based on their previous experiences and ability to apply relevant and recent examples or case studies. An example of this selection basis is the conduct of the mortuary affairs lesson.

Mortuary affairs

This lesson focused on the response of a death of an ADF member in a benign environment and used a recent case study of death in training to identify where a JHO may be required to provide support or technical input, both during and post-death of an ADF member.

Historically, mortuary affairs is not taught until Captain level, except that it is a logistics role and managed at a higher rank than Lieutenant. The Officer in Charge acknowledged this when designing the course but used the opportunity of this lesson to provide a relevant case study to demonstrate that if a death is to occur, and a health officer is present, more often than not they will be required to take charge and provide advice prior to the logistics response.

Lessons learnt

Adjusting a level of tension to meet the level of importance keeps learners engaged and paying attention.[4] This was incorporated during the lesson design. The instructor delivering the lesson, the senior clinician in the Treatment Team who received and treated the patient prior to being declared deceased, provided a detailed and frank recap of the event, including equipment issues, communication systems and the role that the junior Royal Australian Army Medical Corps General Service Officer played in managing the event. This included 'Lessons Learnt' and incorporated the methods used to initiate a Critical Incident Mental Health Support response (which was taught the day prior). This exemplifies the design of a basic conceptual structure for the HOBC. As the course progressed, more complex material progression occurred with links between the previous lessons and incorporation of admissions of 'learnt helplessness'. Included in this lesson was the role that the JHO played in coordinating the response, in the absence of a senior health planner outfield, which enhanced relevance to the trainees and maintained interest throughout the lesson.

Behaviour reproduction

Retention and reproduction are crucial to the learning process. All lesson content taught was imperative for JHOs to retain so that it may be used at a later date. As each trainee came to the HOBC with different levels of prior knowledge, skills and motivation, this influenced their personal learning outcomes. The course design considered this with an emphasis on active learning techniques and reduced information taught.

There is a requirement of a cohesive team when working among the different health corps trades and dynamics. The current training structure does not incorporate the JHOs training together, limiting this cohesion from the early onset. The utilisation of a narrated Role 1 scenario provided an opportunity for the trainees to observe the professionalism and clinical skills required of each member in the team, and the synchronicity required through the actions of the General Service Officer, outside of the Role 1 physical setting.

The trainees observed the clinicians' technical performance within a Role 1 team (including medical technicians) and the interactions between the medical officer, nurse, medics, patient and General Service Officer. This enabled reciprocal determinism and creation of cohesion through the emphasis of teamwork, a notion which was first raised by Bandura. The trainees were then required to demonstrate an understanding of what they had observed by reproducing the narration in their own words.

Motivation

Motivation refers to the trainee being inspired to repeat the learnt behaviour. It can occur in many ways, including vicarious motivation, which is when one learns from others' successes and failures. This learning variable was a key consideration in selecting instructors and the conduct of several informal (peer support) and formal (superior support) networking events during the latter end of the course. A formal networking event was conducted during the Canberra component of the HOBC with over 40 senior health officers attending. Self-determination theory posits that to feel connected and belong is one of the three basic human needs. The purpose of these networking events was to provide the opportunity for the JHOs to meet a base of dedicated and competent health officers from all health streams to further motivate them in the pursuit of professional and personal development. It facilitated the sharing of knowledge and leadership for the trainees to be mentored by senior health officers. Senior health officers were encouraged to share their lessons learnt during their time as a JHO to enable the trainees to learn from previous experiences.

Conclusion

A learning organisation is founded on the learning process of the individual within the organisation.5 The inclusion of predominantly practical activities and interactive lessons in the design of the HOBC enabled positive changes to the conduct of initial training for JHOs (individual and cohort). The course design encouraged reflection and evaluation and demonstrated the benefits of a positive learning environment. It has also provided a baseline for identifying current practice in JHO development and mentoring and is a step in the right direction for quality assurance of the existing health officer training continuum (with opportunities to recommend changes). This is reflected in the decision to incorporate the HOBC as part of the future formal training continuum.

> *'With the short notice task of deploying in support of OP BUSHFIRE ASSIST and faced with a void of information for a seemingly huge task, I fell back on the lessons I had recently learnt at HOBC. Namely, don't make decisions alone; call in the experts for help. During HOBC we had some excellent opportunities to learn about how health elements can be employed outside of the traditional green role and this information armed with a solid foundation going in to a Defence Aid to the Civil Community response.'*
>
> First year Lieutenant (General Service Officer)

The feedback received from the trainees was that this course was highly relevant to the skillset and level of understanding required of them from their respective Units and that it provided a sound understanding of the application of strategic health planning and support across Army. Recommended changes included increasing the length of the course, providing prereading for use of class discussions, the inclusion of more case studies and that the course delivery would be best suited after approximately 4 – 6 months in the trainee's respective unit. Above all, the HOBC was acknowledged by the trainees of building inclusiveness and for the members to establish a positive culture and cohort. This inclusiveness which will contribute towards empowerment and creating a cohesive environment across all health trades and junior officer ranks.

Note - Encouraging feedback and lessons learnt from the first pilot has informed the development of further HOBC in 2020. Unfortunately, the April 2020 course was unable to be conducted due to COVID 19 restrictions. A HOBC was conducted virtually in August 2020.

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Poppy Seed and Prohibited Drug Testing

R Mills

Introduction

This paper presents three 2019 cases of Royal Australian Navy (RAN) personnel with positive tests for urinary morphine attributable to poppy seed (PS) ingestion. All three cases occurred during a period of particularly potent culinary PS in Australia. Australia produces PS with high morphine content for medicinal purposes. Most culinary PS consumed in Australia is imported from elsewhere.

Case one

A 49-year-old senior officer with 24 years RAN service tested positive for morphine (410 ug/L morphine and no codeine or thebaine). This member had volunteered (in advance) for prearranged Prohibited Substance Testing Program (PSTP). On the morning of their PTSP urine testing, this member had eaten two pieces of commercially available (toasted) bread. The member described this bread as being a white loaf with seeds on top. They subsequently determined that these seeds were PS. This member was on no other relevant medication at the time of their PSTP test.

Some months later, this member and their spouse purchased online urine drug test kits for self-testing. They were both negative at baseline and both positive for urinary morphine three hours later after eating two pieces of the same commercially available bread. This member had a negative urinary morphine result the following morning.

Case two

A 53-year-old senior officer volunteered to participate in PSTP urine testing, which they had pre-authorised. This member was not aware that they had ingested PS on the morning of their PSTP urine test. They returned a positive result for morphine (850 ug/L), negative for codeine and thebaine. The member subsequently determined that they had ingested PS by researching the contents of their commercially prepared packaged meals. They had eaten two slices of bread containing PS. This PS content had not been declared on the meal labels.

Case three

A 28-year-old high performing and health-conscious sailor returned a urine morphine result of 380 ug/L (negative for codeine and thebaine) on a random PSTP urine screen. This sailor had not declared PS ingestion at the time of their PSTP urine test. They subsequently determined that a commercially available 'wholemeal and seeds' loaf contained 4% PS. This sailor re-tested negative for urinary morphine after stopping eating the 'wholemeal and seeds' loaf.

It was not possible to independently corroborate the histories provided above. The three individuals' character, their positions within RAN and their laboratory results are all highly congruent with their provided histories.

Literature review

Papaver somniferum is the plant species from which opium and PS are derived. Opiates (which are sometimes referred to as opiate alkaloids) consist of drugs including opium and those derived from opium. The latter group includes morphine, thebaine (also called para-morphine) and codeine. Opium contains both morphine and codeine. Heroin is derived from morphine. Morphine is not metabolised to codeine, but both codeine and heroin (via 6-acetylmorphine [6-AM]) are metabolised to morphine. Codeine, however, is often included as an impurity in illicit sources of morphine. Thebaine is used as a marker of PS origin of opiates.[1-3]

Opioids (including fentanyl, oxycodone and pholcodine) are a synthetic class of drug with the same effect as opiates. Opioids do not contain and are not metabolised to codeine, morphine or 6-AM.

The current RAN PSTP tests for amphetamines, opiates (morphine, codeine, 6-AM and pholcodine), benzodiazepines (multiple), cocaine and THC (marijuana).

PS contain small amounts of morphine and smaller amounts of codeine.[4] Meadway[2] found Australian PS to contain 90ug/g of morphine and 6.5ug/g of codeine. This paper did not document the thebaine concentration.

Typically dietary sources of PS intake will only produce urine concentrations in the hundreds (of ng/mL), but can occasionally produce much higher results.[5] The concentration of ingested PS-based opiates may be significantly higher in PS-based tea (particularly if homemade), than in solid foods. There is a wide range of urine concentrations (of morphine and codeine) from PS ingestion by country of PS origin, between individuals and the same individual at different times.[6]

The ingestion of PS has been reported to persist in urine for up to 48 hours[2] and cause morphine-positive oral fluid test results for up to an hour[7]. One researcher detected morphine in urine up to 1 hour after consuming 820mg PS in a bagel (130–315 mg PS/kg body weight).[8] If the result is positive for morphine and/or codeine and negative for 6-AM, then PS ingestion may be an explanation.[9] A differential diagnosis between heroin and PS consumption using the morphine/codeine ratio does not seem to be possible.[10]

Cassella (1997), found only one subject's urine to include thebaine (along with morphine and codeine).3 The respective post-mortem urine concentrations for this subject were 22, 122 and 47 ng/ml. Thebaine, however, has a shorter half-life than either morphine or codeine. Thus a positive post-PS ingestion urine drug test generally becomes negative progressively for thebaine, then codeine and finally morphine.

There are apocryphal accounts of a person dying after drinking a homemade PS-based opiate concoction in Tasmania[11] and in New York[12].

The Australian cuff-off for morphine is 300 ng/ml. USA has raised its federal drug testing threshold from 300 to 2000 ng/ml, partially in an attempt to reduce the false positive drug tests arising from PS ingestion.[13,14]

Summary

PS ingestion can cause a positive RAN PSTP urine result. Due to a wide variation in PS concentration within food and inter- and intra-individual metabolism, it is not possible to predict how much PS intake is required at a given time to trigger a positive RAN PSTP urine result. Homemade PS-based tea may produce higher results than commercially baked PS products.

Depending upon the amount of PS ingested, this may produce a positive oral morphine result for up to one hour, and a positive urine test for up to 48 hours.

PS can produce positive urine tests for morphine, a lesser concentration of codeine and lesser still concentration of thebaine. Thebaine is specific to PS only. Any other positive substance detected in the PSTP will be from a source other than PS. The laboratory that RAN currently uses for PSTP sample analysis will report a thebaine level greater than 10 ng/ml.

A low range urinary result for morphine can be caused by PS ingestion alone (as little as two pieces of PS containing bread). Coexisting with a lower level of codeine is suggestive of PS, and coexisting with thebaine is diagnostic of PS contribution. A low-level morphine result can also be caused by pure morphine ingestion, heroin ingestion or reflect the tail end of codeine ingestion and metabolism.

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Pelvic Floor Health in Female Military Personnel: A Narrative Review

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Abstract

Background: A growing female workforce within military forces internationally necessitates comprehensive consideration of this population's unique health requirements within a wide range of military contexts. Pelvic floor health is a key area where support needs vary between sexes because of differences in pelvic anatomy and function.

Purpose: To explore what is known about the pelvic floor health of women working in military contexts, specific risk factors and relationships between pelvic floor problems and military occupational health, safety and performance.

Methods: Searches of multiple health and Defence databases identified published studies of relevance to this review's aims. Findings of relevance were extracted and synthesised to provide a narrative overview of the topic.

Findings: From the available studies, genitourinary infections and urinary incontinence were both found to affect up to one-third of serving women. Some self-management strategies used by servicewomen, particularly when deployed, may have negative health consequences. Serving women also identified environmental, equipment and cultural factors that challenged their ability to manage their pelvic health in occupational contexts.

Conclusion: A sizeable proportion of military women experience pelvic floor conditions. Consideration of how to optimise and support the pelvic floor health of female military personnel is required.

Keywords: female, military, pelvic floor

Conflict of Interest: nil

Background

Women are a growing population within the Australian Defence Force (ADF), representing 17.9% of the total workforce (Navy 21.5%, Army 14.3%, Air Force 22.1%).[1] Female participation rates within each Service are steadily increasing and projected to meet the 2023 targets set by each Service (Navy 25%, Army 15%, Air Force 25%).[1] In 2018, remaining restrictions on the roles that female military personnel could undertake within the ADF were removed, paving the way for women to assume roles in combat employment categories, which are considered more physically demanding and diverse.[2] The broader and more diverse roles of an expanding female workforce in the ADF necessitates comprehensive consideration of female personnel requirements in areas such as health care, deployment, physical training, load carriage, and equipment and apparel procurement. The health and welfare needs of female military personnel and veterans have been identified as an area where more Australian data is required.[3] Understanding relevant issues will allow for the provision of appropriate support, training, equipment and health care, and contribute to the ongoing success of women in wide-ranging military roles.[4, 5]

Pelvic health is a key area where the care and support needs vary between the sexes because of differences in genitourinary anatomy and function and their respective roles in reproduction. Pelvic floor health is a broad term encompassing bladder, bowel, sexual and reproductive function, as well as the health of the anatomical structures that house and support these functions. Issues affecting the pelvic floor are often described using the umbrella term 'pelvic floor dysfunction', which encompasses a wide variety of signs and symptoms, such as urinary incontinence, lower urinary tract infection, pelvic organ prolapse, anorectal dysfunction, sexual dysfunction and pelvic pain.[6] The prevalence of pelvic floor dysfunction in the general population is higher for women than men. For example, urinary incontinence, defined as the involuntary leakage of urine, has been found to affect 18–40% of Australian women aged 20–40 years, compared with 2–5% of men in the same age bracket.[7] Pelvic organ prolapse, which refers to the descent and reduced support of the pelvic organs, has been reported to affect between 3–75% of women, with the large variance explained by differences in diagnostic criteria.[8] In comparison, male pelvic organ prolapse is uncommon; thus, the prevalence rate is rarely reported.[9] Urinary tract infections are also more prevalent in women, affecting 1 in 2 women in their lifetime, compared with 1 in 20 men.[10] Overall, it has been reported that approximately 25% of women have at least one type of pelvic floor dysfunction,[11] and it is not uncommon for women to experience co-existing pelvic floor conditions.[12]

The unique factors identified to increase the risk of pelvic floor dysfunction in women compared with men include differences in pelvic anatomies, such as a shorter and straighter urethra, hormonal fluctuations and changes associated with menstrual cycles and menopause, as well as pregnancy and childbirth.[13, 14] While approximately 15% of women do not experience pregnancy and childbirth,[15] the other aforementioned risk factors, along with ageing and ethnicity, are non-modifiable. Obesity and constipation have also been identified in the literature as risk factors for female pelvic floor dysfunction, along with repetitive loading, heavy lifting and high-intensity land-based physical activity.[16, 17] Positive correlations between exercise intensity and loading have also been demonstrated in several prevalence studies of pelvic floor dysfunction (most commonly urinary incontinence) in female athletes.[18]

The preceding background shows that pelvic floor dysfunction is common for women in the general population, and thus, it will likely affect female military personnel. Many military roles' unique physical work requirements mean that personnel undertake high physical training levels and load carriage tasks.[19] Furthermore, military work is often undertaken in austere environments where sanitation can be problematic.[20] These factors may place servicewomen at an even higher risk of pelvic floor dysfunction than women in non-military contexts. Limitations in the amount and quality of obstetric and gynaecological research in female military personnel have also been identified.[21] Therefore, it is imperative that female military personnel's pelvic floor health needs are further understood to enhance health, wellbeing, safety and occupational performance.

On this basis, this narrative review aimed to explore the types, prevalence and severity of pelvic floor dysfunction in female military personnel; consider the risk factors for these conditions; identify the common strategies women use to maintain and manage their pelvic floor health in military contexts; and explore the implications for their occupational health, safety and performance.

Methods

A narrative literature review, defined as a literature synthesis without a systematic quantitative methodology,[22] was chosen because it allowed for the presentation of a broad overview of female military pelvic floor health and achievement of the aims outlined above. Published material of relevance was identified through searches of health and military databases (including CINAHL, EBSCOhost, PubMed, Defence Technical Information Centre and WorldCat) and hand searching the reference lists of relevant studies, between December 2019 and March 2020. The key search terms included female, military and pelvic floor, and no date limits were applied. All types of published material were considered for inclusion in the review (i.e. experimental studies, observational studies, military reports and opinion pieces), as long as they: focused on female military personnel; contained data on types, prevalence, severity or risk factors for pelvic floor dysfunction; explored self-management strategies; and/or discussed implications for occupational health, safety and performance. Published material related to sexual or reproductive function and sexual violence were not included in the review as they were outside the aims and scope. Findings of relevance to the review aims were extracted and synthesised to provide a narrative overview of current knowledge on the topic and areas requiring further research.

Results and discussion

In total, 11 reports from the United States (US) military context were found and provided some initial insights into the prevalence, severity, occupational impacts and self-management strategies used by female personnel for urinary incontinence, pelvic organ prolapse, genitourinary infections and acute pelvic pain (Table 1). No studies were found that examined anorectal dysfunction or persistent pelvic pain in a military context, and no studies focused on pelvic floor dysfunction in female military personnel from other countries, including Australia. The findings of the included studies are synthesised and discussed in the following sections, which address the aims of the review.

Table 1: Overview of studies included in the literature review

Authors	Study details	Sample characteristics	Prevalence	Risk factors	Additional findings	Occupational	Self-management strategies
Davis & Goodman (1996)	UI survey of female airborne infantry trainees (Pre & post-training	N = 512 • 420 nulliparous • 92 vaginally parous Age: 24.5 (21 – 34) 68% Caucasian	Pre-training (UI): • 8% nulliparous • 26% parous Post-training (UI): • 10% nulliparous • 28% parous		9 nulliparous trainees followed up for development of severe UI post-training • 3 UUI • 6 SUI		
Davis et al. (1999)	Cross-sectional survey on UI in active-duty female soldiers	N = 563 Age: 28.3 (18 – 51) Wt: 61.1 kgs Ht: 165.4 cm 75% Caucasian	30% 'problematic' UI	↑ Age ↑ Parity ↑ weight	Onset: 5 yrs Aggravated: • physical training • field activities	31% UI adjusted training/duties Job roles associated with higher UI: • Petroleum techs • Cooks • Supply	Pre-activity voiding or pad use = 68% Fluid restriction = 13 – 19% PFM ex = 19%
Fischer & Berg (1999)	Cross-sectional survey on UI in active-duty female Air Force crew	N = 274 respondents Age: 32.9 years	26% experienced UI • 70% SUI • 32% on-duty • 18% flying	↑ Age ↑ Parity Crew position	89% UI episodes off-duty	Navigators, weapon system operators, electronic warfare operators had higher rates of UI Type of aircraft (high vs lower gravity loads) did not influence UI	
Larsen & Yavorek (2007)	Prospective cohort study nulliparous military cadets Pre & post-training (UI and POP)	N = 116 n = 37 paratrooper Age: 20.7 (19 – 24)	Pre-training: • UI = 15% • POP 1 = 46% • POP 2 = 2% Post-training • UI = 21% • POP 1 = 54% • POP 2 = 22%		Paratrooper trainees ↑ risk of worsening pelvic organ support (RR = 1.57)		Fluid restriction Pre-activity voiding
AHFSC (2014)	Retrospective data analysis (UTI) from US Defence Medical Surveillance System 2000- 2013	Active-duty Navy, Army, Air Force, Marines, Coast guard	UTI • 30.4% females • 3.5% males UTI recurrences • 41.3% females • 13% males		Female groups with ↑ incidence • Army & Marine corps • Junior enlisted • Singles Coast guard ↑recurrence	2240 hospital bed days/year 4981 days lost work time/year	
Wright et al. (2006)	Retrospective data analysis acute female pelvic pain presentations (combat environment)	N = 150 pelvic pain (14% gynae cases) Age: 28 (15 – 53) 98% female army 45% active duty 41% reserves	19.3% pelvic pain (unknown cause) 16% UTI 6.7% LUTS		75% only seen once	75.3% returned to active duty 8.7% medical evacuation	
Lowe & Ryan-Wegner (2003)	Cross-sectional survey female active duty and reserve Navy, Army & Air Force (deployed past 5 years)	N = 841 Age: 28.3 (18 – 56)	18.4% UTI (deployed) 30.1% VVI	Previous infection ↑ no. behavioural factors Austere environment characteristics (VVI only)	50% reported >4 behavioural factors: • Holding urine • Tampons • Antibiotics • OCP • Non-cotton underwear • Douches • Sexual intercourse • Steroid use	Deployed living conditions: • 52.5% tent • 18.5% barracks • 15.5% ship • 13.5% other	

Authors	Study details	Sample characteristics	Prevalence	Risk factors	Additional findings	Occupational	Self-management strategies
Czerwinski et al. (2001)	Cross-sectional survey on feminine hygiene practices in military (all Services)	N = 880 usable surveys Age: 41 (20 – 65) Navy 23% Army 42% Air Force 29% Marine 6%			Maintaining hygiene when deployed more challenging – less, privacy, less facilities, unsanitary	Deployed settings – impacts shower and handwashing frequency, choice of sanitary items and underwear	Sanitary items Douching Handwashing Showering
Criner (2008)	Cross-sectional survey of female military personnel with SUI	N = 69 Age: 40 (19 – 62) BMI: 25.4 (17.2 – 44.1) Ht: 163cm Wt: 66.7kgs 68% Officers 30% nulliparous 94% mild-mod SUI			13% sought help 42% withheld feelings 51% refused to think about problem	↑ field barriers = more coping strategies ↑ field barriers = ↓ QOL ↑ symptom distress = ↓ QOL in field	78% PFM ex 78% panty liners 71% ↓ fluid intake 67% underwear changes 62% ↑ voiding 17% avoided ex 8.7% avoided strenuous work
Wilson & Nelson (2012)	Ethnographic study on female genitourinary management in deployed settings	N = 43 Age: 27 (20 – 49)			↓ use of medical services: • ↓ trust • ↓ education • ↓ privacy • ↓ experience • ↓ resources • ↓ cleanliness • provider gender • stigma	Challenges: • Uniforms (heavy, hot, restrictive) • Laundry • Toilet facilities • Shower facilities • Supply availability • Weather • Prophylactic antibiotics • Lack of privacy • Job requirements/ hours	Planning ahead Bringing own supplies Maintaining hygiene Voiding as able FUDD Hydration Underwear changes Menstrual control Support from home
Steele & Yoder (2013)	Narrative review of female military urinary practices				Recommendations: • CPG on GU health in deployed settings • Pre-deployment self-care modules • Equipment provision (FUDD, antimicrobial underwear, female-specific uniforms - research	Field challenges: • ↓ privacy • Crowded living • unsanitary conditions • ↓ toilet/ shower/ laundry facilities • Safety/security concerns • uniforms/ equipment	Urinary practices: • Restrict fluid intake • Delayed voiding • Squatting over bottles • Pads

Abbreviations: UI = urinary incontinence, SUI = stress urinary incontinence, UUI = urge urinary incontinence, PFM ex = pelvic floor muscles, POP1 = pelvic organ prolapse stage I, POP2 = pelvic organ prolapse stage II, UTI = urinary tract infection, LUTS = lower urinary tract symptoms, VVI = vulvovaginal infection, OCP = oral contraceptive pills, QOL = quality of life, ex = exercise, FUDD = female urinary diversion device, CPG = clinical practice guideline, GU = genitourinary

Prevalence, severity and risk factors

Prevalence data in female US military personnel have been reported for urinary incontinence,[23-26] pelvic organ prolapse,[26] genitourinary infections,[27-29] and acute pelvic pain.[28] Urinary incontinence prevalence rates for female military personnel and trainees were reported to range from 8–30%;[23-26] which is on the lower end of prevalence rates reported for the general population of Australian women aged 20–40 years (18–40%)[7] and female athletes (19–70%).[18] The slightly lower range of prevalence rates in female military personnel studies may be due to their generally younger age and lower parity, which are commonly reported risk factors for urinary incontinence in women.[11, 30] Key limitations of the available prevalence data for urinary incontinence were there was only a limited range of military roles and contexts included in studies, and none from a Navy context, and the available studies were conducted between 13 and 24 years ago.[24, 26]

The severity of female military personnel's urinary incontinence symptoms has not explicitly been investigated but was briefly reported in two studies.[23, 31] In the survey of US Army women by Davis and colleagues (1999), 31% of women with urinary incontinence stated that it was at a level they deemed a 'social or hygienic problem'. The severity of symptoms was influenced by the activity performed, physical training, field activities and recreational exercise most commonly contributing to symptoms. In addition, over 25% of women with symptoms experienced them greater than 50% of the time during physical training.[23] However, it is not clear from the information reported how severe the symptoms experienced were and how, if at all, they influenced occupational performance. In a cross-sectional survey exploring 69 female US servicewomen's coping strategies with stress urinary incontinence, 94.2% reported that their symptoms were mild to moderate,[31] which is similar to general population studies. For example, 74% of Australian women reported their urinary incontinence symptoms as 'slight', with the severity of symptoms increasing with age.[7] While the available information suggests that urinary incontinence symptoms are predominantly mild to moderate for female military personnel, the impact of these symptoms on occupational performance is unclear.

The influence of military training on the prevalence of urinary incontinence was assessed in two US studies of female military trainees.[24, 26] Small increases in the percentages of women reporting urinary incontinence post-training were reported (2–6%). While these increases were not statistically significant, they suggest there may be a relationship between higher levels of physical training or loading and the risk of urinary incontinence. Lending support to this possibility, nine nulliparous trainees who developed severe urinary incontinence after their training were followed up by Davis and Goodman (1996). Three of these women developed urge urinary incontinence, or urinary leakage associated with a feeling of urgency, and the remaining six severe stress urinary incontinence, or involuntary urinary leakage with physical exertion.[6] Physical examination of the six women with stress urinary incontinence revealed co-existing bladder prolapse, or descent and bulging of the bladder into the anterior wall of the vagina, which was not detected on pre-training pelvic examination. Five of these women identified a particular event (landing from parachute jump/ lifting a heavy load) that preceded the onset of symptoms, which indicates that particular types of loading may contribute to changes in pelvic floor support and symptom development.

Similarly, a relationship between type and dose of physical training and the prevalence of stress urinary incontinence has also been reported in female athletes. Athletes more frequently engaged in higher impact activities (i.e. jumping) and higher training levels reported a greater prevalence of urinary incontinence.[16] Limited details were provided in the available military studies about the types and intensities of training activities military cadets and trainees were engaged in, and how these differed from their usual physical activities. The duration of training and the reassessment period were also not clearly defined. Larsen and Yavorek (2007) reported that training (and subsequent reassessment) was undertaken over the summer months,[26] indicating a reasonably short duration of training. Therefore, the effects of ongoing high physical training and occupational task loads were not considered and require further investigation. However, these findings suggest that the types and amount of physical loading female military personnel undertake in the workplace could impact the development and severity of urinary incontinence symptoms. Reviewing military training programs and considering how training is scheduled and progressed regarding pelvic floor stress may be a simple strategy for preventing or minimising the risk of urinary incontinence.

The prevalence of pelvic organ prolapse and pelvic organ support changes after initial training in nulliparous female US military cadets were assessed in one study.[26] Prior to training, 46% were assessed to have stage I pelvic organ prolapse (lowest point of prolapse >1cm above hymen[32]) and 2% stage II prolapse (lowest point between 1cm above and below hymen[32]). These findings are not dissimilar to those from population-based studies for stage I pelvic organ prolapse in women aged 18–83 years.[8] After training, a decrease in pelvic organ support was found, with 54% of cadets assessed as stage I and 22% with a stage II prolapse. Female cadets participating in paratrooper training (n = 37) were also found to be at an increased risk of worsening pelvic organ support (RR = 1.57) compared with other trainees. Again, these findings allude to a potential relationship between the level of loading experienced by military women and pelvic floor symptoms, which may have implications in military roles requiring a high volume of heavy load carriage or intense physical training. Occupational factors have previously been linked with the risk and severity of pelvic organ prolapse, with labourers and factory workers shown to be at greater risk than other occupational categories.[33] However, a causal dose-response relationship between physical activity, repetitive loading on the pelvic floor and pelvic organ support has yet to be confirmed,[34, 35] with stronger relationships between pelvic organ prolapse and ageing, parity and the number of vaginal deliveries consistently found within the literature.[35] Females within the military will experience ageing, and many will also experience pregnancy and birth during their careers, while also undergoing high levels of physical and occupational loading. Therefore, strategies to prevent and manage pelvic organ prolapse need to be considered within military training programs.

Fourteen per cent of women presenting for gynaecological care within a combat environment were found to be affected by acute pelvic pain.[28] One-quarter of these presentations were attributed to genitourinary infections, but 19% had no clear aetiology. Urinary tract infections are a significant issue for female military personnel, with reported prevalence rates of 18–30.4%, which is much higher than in men (3.5%).[27, 29] Recurrence rates for women are also higher (41.3%) when compared with men (13%).[29] The risk of infection is also higher in women who have previously had a urinary tract infection.[27] Vulvovaginal infections are characterised by symptoms of vulvovaginal itching, burning, pain and discharge, and have a reported prevalence rate of 30.1% in deployed settings.[27] Similar to urinary tract infections, previous vulvovaginitis history was a key risk factor, along with medication use (i.e. steroids, antibiotics, oral contraceptives), delayed voiding and tampon use.[27] Poor sanitation in deployed environments, as well as more challenging toilet practices due to the work context, location, apparel and equipment, may also be contributing factors to genitourinary infections.[20, 36] The aforementioned issues associated with deployments highlight common occupational challenges that female military personnel face in maintaining and managing their pelvic floor health.

Occupational Challenges

A range of occupational challenges has been identified that may negatively impact female military personnel's pelvic floor health, particularly in austere field and deployed environments. Moreover, these challenges and their potential impacts on the pelvic floor, may influence work performance and negatively impact military operations. In an ethnographic study of female military personnel and their genitourinary management in deployed settings, Wilson and Nelson (2012) categorised the challenges for military women under three broad headings: (1) those coming from the work environment; (2) those associated with equipment; and (3) those associated with workplace culture. Servicewomen's common environmental challenges included the climate, availability and cleanliness of bathroom and laundry facilities, crowding, decreased privacy, safety and security concerns, and variable availability of supplies, i.e. sanitary items.[20, 31, 36, 37] The climate can influence pelvic floor health in different ways. For example, hot and humid climates are associated with increased sweat and heat in the genital region, increasing bacterial growth and risk of infection. Areas with high risks of malaria may require personnel to take prophylactic antibiotics, which many women feel increases their risks of genitourinary infection.[36] Several studies have shown that antibiotic use can increase vaginal bacterial growth and the risk of vulvovaginal infections, particularly in women with previous infections.[38, 39] Coupled with often limited access to clean bathroom and laundry facilities, maintaining the level of hygiene required to minimise the risks of genitourinary infections then becomes difficult.[20, 27, 36, 37]

Equipment can also pose a challenge to maintaining female pelvic floor health, with restrictive and heavy uniform fabrics reported to increase heat and moisture retention in the genital region, predisposing women to genitourinary infections. Uniform design and the need to wear protective gear or carry additional equipment and weapons can make toileting in the field awkward, time-consuming, and where there are no facilities, embarrassing and dangerous due to exposure.[20, 36] It may also pose a safety and security risk to the individual and their unit.[20]

The setting's culture may also influence pelvic floor health by impacting self-care and health-seeking behaviours. The level of pre-deployment education offered by units influenced women's knowledge of strategies to prevent and manage common pelvic health conditions and the level of trust women had in their Commanding Officers and healthcare providers.[36] Many women reported that they were reluctant to seek health care while deployed due to the need to seek permission and a lack of trust in medical providers. A lack of confidentiality, experience, supplies, clean and safe healthcare environment, and the gender of the medical provider all influenced servicewomen's trust and decision making about accessing health care for pelvic floor dysfunction while deployed. Moreover, gossip generated and perceived stigma about their promiscuity also created barriers to self-management and pelvic floor health-seeking behaviours for servicewomen.[36] For many women this led them to seek information and advice from other sources, such as trusted colleagues and family members, ignore symptoms or delay seeking medical treatment until after they had completed their deployment.[36]

Self-management strategies

Female military personnel utilise a wide variety of self-management strategies to prevent and manage symptoms (Table 1).[20, 23, 31, 36] The most common strategies include maintaining genital hygiene, utilising methods to control menstruation, altering fluid intake and voiding patterns, using sanitary items to manage periods and episodes of urinary incontinence, changing underwear frequently, and pelvic floor exercises to improve bladder and bowel control. The strategies utilised have been reported to vary between when women are home and when in deployed settings. In deployed settings, women needed to plan ahead, bring additional supplies of sanitary items and self-management treatments (i.e. fungal creams), order items online or request care packages from home, utilise larger absorbency sanitary items to account for changeover delays, and wear cotton undergarments.[36, 37] Modifying aspects of physical training or work roles was a strategy utilised by some military women to reduce their symptoms of urinary incontinence.[23] However, very few servicewomen completely avoided exercise or strenuous work tasks (8–17%).[23, 31]

Of concern for military organisations, is that some of the self-management strategies used by female personnel to manage their pelvic floor health at work may be associated with a range of negative consequences. Limiting fluid intake was a common strategy identified by women to reduce the need to urinate in environments that may pose challenges, or to minimise the risk of urinary incontinence episodes.[20, 23, 27, 31] However, when fluid intake is limited, the risks of dehydration increase, which may lead to reductions in occupational performance, and an increased risk of heat-related illness and urinary tract infections. Alterations in voiding patterns, such as delaying voiding or frequently voiding, can also have negative consequences. Prolonged holding can lead to pain and urinary tract infections and increase the risk of urinary incontinence episodes. On the other hand, voiding at any opportunity with low bladder volumes may lead urinary frequency and urgency issues. Frequent use of panty liners, pads and tampons to manage urinary incontinence, menses or vaginal discharge may increase the heat and moisture around the genital region, increasing the risk of genitourinary infections. Regular changes of sanitary items may also not be possible in the field due to the nature of the work or a lack of suitable toilet facilities. This further increases the risks of infection, and in the case of internal sanitary items like tampons, more serious sequelae such as toxic shock syndrome, which can be life-threatening.[40] In austere field environments, limited handwashing facilities may likewise increase the risks of infection. Moreover, avoidance of healthcare services may lead to recurrent or more serious genitourinary infections (i.e. pyelonephritis) or health issues. By understanding the common self-management approaches used by servicewomen and their risks, pragmatic prevention and management strategies can be developed and tested.

Prevention and management strategies

Strategies for maintaining and managing pelvic floor health of servicewomen in the varied military workplace environments were not a primary focus for this review. However, the review findings demonstrated that a sizeable proportion of women in military roles experience pelvic floor dysfunction at work. Therefore, if military organisations can help servicewomen prevent and manage pelvic floor dysfunction to optimise their health and occupational performance, this warrants consideration and further research.

Improving pre-deployment 'women's health' programs is one recommended preventative measure,[20] and was tested in one study using a health promotion model. Trego and colleagues (2018) investigated the 'reach, effectiveness, adoption, implementation and maintenance of a pre-deployment female genitourinary health program'. The program objectives were to educate military women on challenges in maintaining pelvic floor health in austere environments, signs, symptoms and rates of common health issues, strategies for preventing problems and the use of valuable equipment such as female urinary diversion devices (FUDD). The program was well-accepted by military units and implemented as instructed. Of the 1087 women eligible to participate, 41% chose to complete the education program. A decrease in diagnoses of common genitourinary conditions at an organisation level was seen 12 months after program implementation. At twelve months, many women continued to use the FUDD, but at an organisational level, 22 out of 35 units had no plans for continuing to use the program in their routine training. Therefore, women's health education programs may be beneficial in the short term for improving genitourinary health outcomes, but require organisational support for their implementation and maintenance.[41]

Some research has also been undertaken on prevention and management options for genitourinary infections. Self-diagnosis and management kits to overcome some of the factors limiting women from seeking health care for genitourinary symptoms in the field were developed, tested and found to be simple, accurate and well-accepted.[42] In addition, women were able to use them accurately with minimal training levels (20-minute video). The advantages of the kits were that they allowed women to quickly and discreetly diagnose genitourinary infections and commence management in a timely fashion with minimal use of healthcare resources. Early treatment may also prevent more severe complications and minimise potential occupational impacts.[20]

Education programs and self-management kits, such as those described above, are positive examples of the types of strategies that can be used by military organisations to prevent and manage pelvic floor dysfunction in female personnel, and further research in how to optimise their design and use is warranted. Other well-researched management strategies, such as pelvic floor muscle training, commonly used to treat pelvic floor dysfunction in the general female population, should also be considered when developing pragmatic, resource-efficient and effective prevention and management strategies for female military personnel.

Limitations of the literature within the review

Female pelvic floor dysfunction incorporates a wide variety of health issues. A limitation of the available research reports included in this review is that they have only considered a limited number of conditions within pelvic floor dysfunction—urinary incontinence, pelvic organ prolapse and genitourinary infections. To enable a complete understanding of the pelvic health of female military personnel and how it influences occupational performance, other conditions, such as anal incontinence, persistent pelvic pain, and sexual dysfunction also need to be considered in future research, as well as the co-existence of multiple pelvic health issues. Many of the available studies were over five years old and may not accurately represent contemporary military women and the wide variety of roles they undertake. No published data providing insights into the Australian military context, where the culture, resources and support provided might be different from those in other regions of the world, were found. The review was also unable to identify any available studies that could provide comparisons of female pelvic floor health between different Services.

Conclusions

This narrative review is the first known review to broadly explore pelvic floor health in female military personnel by synthesising available research on prevalence, severity, risk factors, occupational impacts and self-management. From the limited volume of evidence available, pelvic floor dysfunction was commonly experienced by servicewomen. Environmental, equipment and cultural factors (particularly in austere field and deployed settings) were shown to present challenges for women in maintaining their pelvic health at work. In addition, behavioural factors associated with managing genitourinary function at work, such as altered voiding patterns and fluid restriction, posed risks to occupational health and safety. Some initial research into implementing organisational-based approaches to preventing and managing pelvic floor dysfunction in female military personnel has shown some positive results. By identifying and understanding female military personnel's pelvic floor health needs, risk mitigation strategies can be informed, and Defence force capability optimised.

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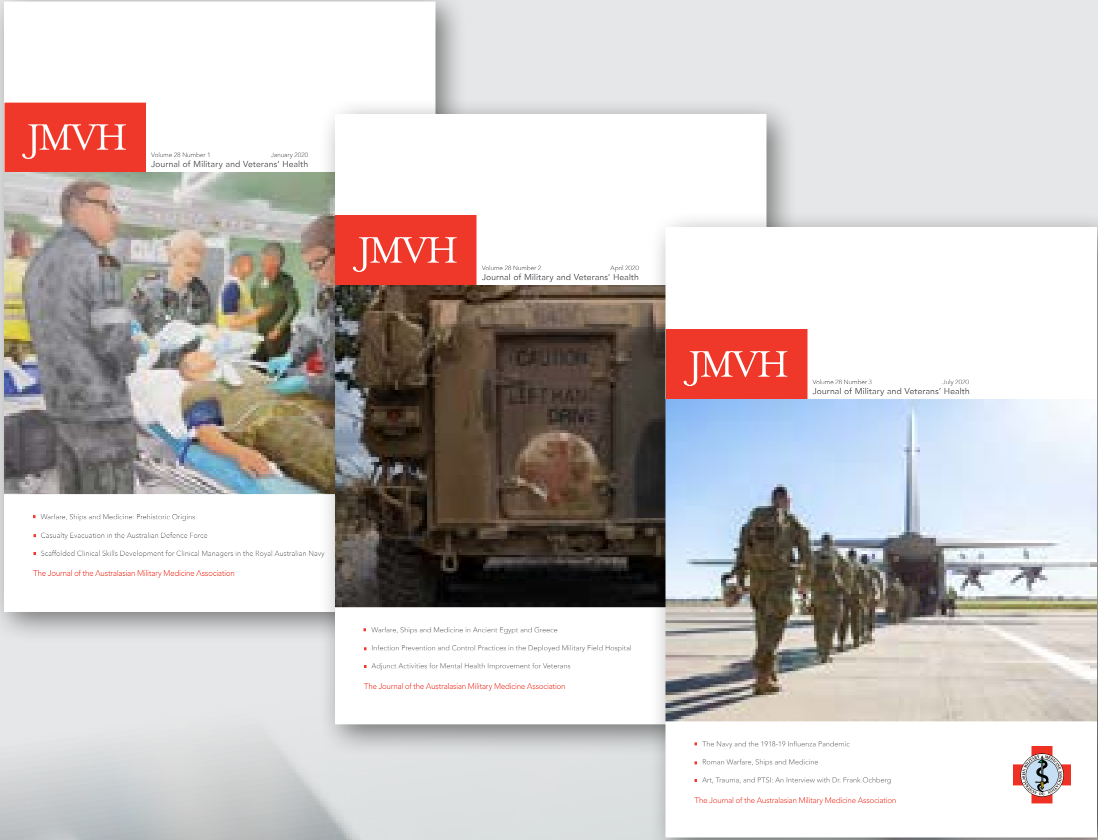
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