RETROSPECTIVE ANALYSIS OF THE ETHNIC ORIGINS OF MALE BRITISH ARMY SOLDIERS WITH PERIPHERAL COLD WEATHER INJURY

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Abstract

Objectives: To determine if African Americans, Pacific Islanders and Gurkhas have a different incidence and severity of peripheral cold injury when compared to Caucasians in the British Army.

Method: The design was a retrospective analysis of those British male army personnel aged over 18 assessed at the Institute of Naval Medicine Cold Injury Clinic. The participants were 311 patients assessed on first attendance at the UK Institute of Naval Medicine.

Results: After excluding those classed as normal, African Americans had a relative incidence of 30.36 (95% CI 25.82 – 35.70) when compared to Caucasians; Pacific Islanders a relative incidence of 2.58 (CI 1.24 – 5.38), again against Caucasians. Being of Gurkha ethnicity proved protective, with no abnormal cases found on assessment. The African Americans were more severely affected than Caucasians, with mean scores of 5.39 (SD 1.767) against 4.24 (SD 1.994) for Caucasians. The severity of Pacific Islanders were similar to Caucasians. The ages of African Americans, Pacific Islander and Caucasians had similar means of 26.05, 26.30 and 26.68 respectively, but with a broader age range for Caucasians; SDs 3.428, 2.958 and 7.735.

Conclusion: Young male African Americans in the British Army are at 30 times greater chance of developing peripheral cold injury and are more severely affected than their Caucasian counterparts following similar climatic exposure, using similar clothing and equipment. Pacific Islanders are at a 2.6 times increased risk, while being a Gurkha is protective.

Key Words: Ethnicity; African American; Pacific Islander; Gurkha; military training; peripheral cold injury; frostbite.

Introduction

Clinical observation of soldiers presenting with peripheral cold weather injury (CWI) indicated that those from Commonwealth countries, particularly African Americans and Pacific Islanders, appeared overrepresented following the UK's cold winter of 2005 – 2006. Over the last decade the Army has actively increased its recruitment of non-Caucasians. Not only has there been a desire that the British Army should better reflect society, but active recruitment has occurred in Fiji and the Caribbean where recruitment of high calibre, well educated soldiers has been easier than UK.

Cold injuries occur as a result of the effects of cold wet and cold dry conditions on the body. The conditions fall into primary generalised which is mainly hypothermia, and primary localised, consisting of frostbite and non-freezing cold injury.

This study investigated those primary localised cases seen on first occasion at the Institute of Naval Medicine (INM), and included suspected freezing and non-freezing cold injury cases referred from primary health care. Both freezing and non-freezing cases are contained under the umbrella term "peripheral cold weather injury". Non-freezing cold injuries occur at 0° – 15°C, while freezing conditions occur below 0°C in dry conditions, with exacerbations by wetness, wind chill and altitude [1].

Risk factors for the development of frostbite include poor clothing, consumption of alcohol and inappropriate use of shelter. Physiological factors such as dehydration, hypoxia and high altitude also affect the incidence. Underlying medical conditions include diabetes, peripheral vascular disease, Raynaud's phenomenon, psychiatric illness and previous frostbite. Risk factors for peripheral cold injury include immersion in cold water, wet poorly insulated clothing, constrictive clothing and boots, prolonged immobility, hypothermia and crouched posture, conditions frequently encountered in military campaigns [2]. The majority of soldiers referred to the INM Cold Injury Clinic suffered from non-freezing cold injury. The condition causes intense pain, acutely, and for many months thereafter. It can recur after new exposure to cold and wet conditions and frequently results in medical discharge from the armed forces.

Non-freezing cold injury occurs when tissue fluids do not freeze but the local temperature remains low for several hours or days; the commonest site is the feet. There is usually anaesthesia, with the individual describing a 'feeling of cotton wool', with severe vasoconstriction. Rewarming is followed by cyanosis, then hyperaemia, redness, swelling and severe pain. This phase may be followed by sensitivity to cold exposure with recurrence after mild re-exposure to cold conditions. The pain is usually resistant to normal analgesics, even opiates, with best results from the early commencement of amitriptyline [3].

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In a Norwegian study, affected limbs were subjected to ice cold water and the expected normal cold induced vasodilatation was profoundly delayed. The affected limbs also showed the lowest skin temperatures after 15- 20 minutes of immersion [4]. The transcutaneous oxygen tension was decreased, but oxygen reappearance time, oxygen recovery index, post occlusive reactive hyperaemia, and venoarterial reflex were normal. The data demonstrated disturbances of reflex mechanisms mediated by the central nervous system. Neurophysiological factors seemed more important than ischaemic mechanisms in the pathophysiology of late sequelae peripheral CWI.

In severe non-freezing cold injury there is characteristic peripheral nerve damage and tissue necrosis [5]. Clinical sensory tests indicated damage to both large and small diameter nerves. The ethnic origin of those affected with CWI could be associated with the known higher incidence in African Americans of hypertension [6], diabetes [7] and stroke incidence [8]. Polynesians have a much higher incidence of diabetes than Europeans [9].

The first anecdotal reports of cold weather adversely affecting ethic groups come from the American Civil War when blacks were reported as more susceptible to cold injury [10]. The American Army reports from the Second World War [11] highlighted ethnic origins in CWI during the cold winter conflict in the Ardennes in 1944 showing an increased incidence in African Americans.

A study from Alaska, [12], showed that both African American men and southern born men, regardless of race, were at greater CWI risk when stationed in Alaska. In a detailed quantitative study, [13], that examined the risk factors in American Servicemen in Alaska over a three year period and 292 cases of frostbite, African-Americans were 2.8 times as susceptible as Caucasians. Persons born in warmer climates and those with previous cold injuries had an increased incidence. Caucasians with blood Group O appeared more susceptible than types A or B. Cigarette smoking increased the risk 1.4 times, while increased rank, education, and experience in the sub arctic were associated with a lower incidence. Age, weight and height had no effect.

In Alaska, a 5 year study of American soldiers [14] found that male African-American soldiers were significantly more susceptible to frostbite than male Caucasian soldiers, especially in regard to frostbite of the distal extremities. The relative incidence was 3.94; 95% confidence interval 2.77 – 5.59. Other identified risk factors were inadequate clothing, dehydration, inactivity, fatigue and previous CWI. An American Army study from Germany [15], showed that 64% of the injured soldiers were African-Americans, while they comprised 28% of the local army population.

A small study in US Marines on a long Arctic ski trek concluded that prolonged heavy load carriage may have impaired blood flow or nerve conduction in the hands and inhibited acclimatisation [16]. In the British Army, prolonged weight carriage is commonly seen in the infantry, the sector with greatest concentration of Commonwealth soldiers, potentially increasing CWI and their relative incidence against Caucasians.

A large retrospective study of all US Army cold weather injuries spanning two decades, [17], examined 2,143 hospitalisations. The injury rates for men and women were virtually identical, 13.9 and 13.3 / 100,000 soldiers respectively. The authors additionally demonstrated that an increase in rank was associated with a decrease in CWI. Similarly the youngest had the highest frequency and rate, with 80% of those injured having less than 5 years of service. The infantry and gun crews were disproportionately affected. Overall African-Americans were hospitalised at 3.3 times the rate for Caucasians, (95% CI 3.1-3.7). The researchers also noted a dramatic decline in hospitalisations over the twenty year period, from > 30 cases per 100,000 soldier years to almost zero.

The recent and detailed report from Alaska of all CWI cases in civilians and Military, highlighted the raised incidence in African-Americans with normal rates for Alaska Natives and whites [18]. The African-Americans comprised 30% of the injured (12/40), against their representation in the Alaskan population of 4%. Their relative incidence was approximately 10.7.

An Indian study into peripheral vascular responses during local cold stress was undertaken in 4 groups of Indians: South Indians, North Indians, Gurkhas and High Altitude Natives (HAN) of 3,500m. The heat output and cold induced vasodilatation (CIVD) were highest in HAN, the lowest in South Indians. The authors [19] quoted earlier studies that showed that individuals with higher heat output and CIVD are better protected against the occurrence of cold injuries, suggesting that HAN are most resistant to the occurrence of cold injuries.

The Falklands war produced the first British paper to include ethnicity and possible CWI relationships, [20]. The British Army had a very different ethnic mix in 1982 to that of 2006, but of the 4 African-Americans in 3 Para at the time all had suffered from peripheral CWI. There were no African-Americans in the Scots Guards battalion in the Falklands campaign.

None of the recent civilian studies, including British Antarctic Survey staff, high altitude climbers in Iran, Spanish climbers in the Himalayas, and Fins in their home country, have shown any correlation with ethnicity and CWI. Reasons include small sample size and the ethnic homogeneity of the populations being studied. However, none of these studies sets out to demonstrate such a correlation.

Procedures at Institute of Naval Medicine Cold Injuries Clinic

All patients who attended the INM Cold Injuries Clinic (CIC) underwent similar investigative procedures by a single specialist, the Head of Survival and Thermal Medicine. The assessments were undertaken a minimum of three months from initial injury, by which time the hyperaemia caused by the injury should have subsided. All patients had infra-red thermography of feet, hands or both. The procedure cools the extremities and then takes timed infra-red photographs during the rewarming process. The extent of cooling and time to return to normal or near normal functioning is measured. Although computer recording has been tried in the department, the varying shape and size of extremities caused difficulty and each photograph is graded by eye by the one observer. The observer has been tested for intra-observer reliability for a previous project and compared against another observer, [21]. This report additionally examined the validity of thermography in assessing non-freezing cold injury Thermography has been used successfully in the assessment of Raynaud's [22] and the rationale for using thermography in peripheral cold injury assessment is well described [23].

Patient are graded on a 9 point scale with the following descriptors: Normal, Within Normal Limits, Lower Limit of Normal, Mild, Mild / Moderate, Moderate, Moderate / Severe, Severe, Very Severe. Additionally, as patients with this condition suffer pain and sensory changes, each patient had thermal sensory thresholds measured for fingers and toes whereby the digits were heated or cooled by a controlled but varying amount and patients asked to record when a change in warmth or coolness was detected. The results were recorded as a degree and fraction of degree for hot and cold in fingers and toes. These processes and recording are automated.

Of the new patients seen in 2005 – 6, [24], 74% were Army, 20% Royal Marines with 4% RN, 2% RAF and 4% of the total female. 49% were Private soldiers or equivalent and 26% of the total were in training; only 4% were Senior Non Commissioned Officers or Warrant Officers and 3% Officers. Of the total, 74%

had suffered non-freezing cold injury and 24% freezing cold injury. Only 10% gave a history of a previous episode. 58% occurred in the feet only, 22% hands and feet, 17% hands only and 2% in the face. 62% had occurred in the UK, 29% in Norway, mostly the Royal Marines, 7% Germany and 2% Poland. Following their initial appointment, only 16% returned to full duties, 71% having restrictions placed on their employment. Medical discharges were recommended immediately for 5%, while a further 7% were thought likely to be medically discharged.

From past INM experience, many of those who suffer do not present initially but report after further episodes of cold injury. Previous studies at INM have indicated that around 15 – 20% of those who present at the clinic with non-freezing cold injury go on to medical discharge.

Methods

The study protocol was approved by the UK MOD Research Ethics Committee for those aged 18 and older. Females were excluded as historically they have constituted only 5% of total INM referrals. This study was a hypothetico – deductive, retrospective study of male Regular British Army soldiers seen at first attendance at the Institute of Naval Medicine during the years 2005 and 2006, which followed the cold winter of Nov 05 – Mar 06. The study took the Caucasian population of males over 18 and compared the relative incidence of ethnic groups of African-Americans, Pacific Islanders and Gurkhas against this control and was suitably powered to detect a difference in severity with a sample size of 82 to achieve a 2 tail effect of 0.3, α of 0.05 and 1 – ß of 0.8, or sample size of 191 for 2 tail effect of 0.2.

The following patient identifiers were added to an Excel spreadsheet: regimental number, surname, first name, date of birth, date seen in clinic. The severity data from Normal to Very Severe as given by the CIC at INM, were coded from 1 – 9 and manually entered into the spreadsheet. No ethnicity data was held by INM; this was obtained from the Defence Analytical Services Agency (DASA) in Upavon. The ethnicity data was added by DASA staff utilising the Regimental Number and date of birth as a check. DASA additionally added Nationality data that provided a check indicator on ethnicity.

The patient identifiers, along with age, severity code and ethnicity code were entered onto SPSS. SPSS was used to calculate frequencies, mean scores comparing ethnicity to severity and ethnicity to age, and Kolmogorov – Smirnov tests. To provide the control population, DASA supplied Regular Army population data for 1 Jan 05 and 1 Jan 06. The differences in overall numbers between years were small, but showed an overall reduction, a reduction in Caucasians and Gurkhas with increases in African-Americans and Pacific Islanders.

The main reliability concern is the accuracy of the DASA ethnicity data as provided to that organisation. The ethnicity data is voluntarily given by potential soldiers on joining and could be false by accident or design.

The relative incidence (RI) for each ethnic group was calculated as follows:

$RI=(a/b)/(c/d)$

where:

- a = Number in ethnic group in Army, less under 18 and females.
- b = Number of that group assessed at INM.
- c = Number of Caucasians in Army, less under 18 and females.
- d = Number of Caucasians assessed at INM.

This study used CIs of 95% throughout. SPSS calculated the Independent Samples t-test for ethnicity against severity and ethnicity against age producing Levene's Test for Equality of Variances and the t-tests for equality of means.

Results

311 eligible new cases were seen at the CIC in INM between 1 Jan 05 and 31 Dec 06. All cases fitting the criteria were suitable for inclusion in the subsequent analysis. One hundred and forty six were Caucasian, 137 African American, 16 Pacific Islanders, 1 Gurkha and 11 Others. The 9 patients with ethnicity of Mixed Black Caribbean / White or Mixed Black African / White and Nationality of British, Zimbabwean or St Lucian were placed in the 'Other' category. This action reduced the relative incidence for African-Americans when compared against Caucasians. The control population is represented in Table 1.

Ethnicity	Number
Caucasian	83,385
African-American	2,936
Pacific Islander	1,951
Gurkha	3,505
Other	8,467
Total	**100,243**

Table 1. Army Population Averaged, excluding females and those under age 18.

The cases were combined with the average Army population for years 2005 – 2006 to produce a new case attendance rate per 100,000 for each ethnic grouping. These figures were then taken to produce a RI figure for all ethnic groupings, using the Caucasian population as the control. The crude Relative Incidence scores are in the Table 2. A breakdown by severity code is at Table 3. Of the 16.4% Normal or Within Normal Limits, 30 were Caucasians, 13 African Americans, 9 Pacific Islanders and 1 Gurkha. Those graded Normal or Within Normal Limits were then excluded from further analysis to remove cases of overcautious referral or diagnostic doubt. When these cases are withdrawn, the RI for African Americans increases while that for Pacific Islanders decreases, as in the Adjusted RI in Table 2.

Ethnic Group	Crude RI: Group to Caucasian	Adjusted RI: Group to Caucasian
Caucasian	**1.00**	**1.00**
African-American	**26.65 (CI 22.85 - 31.08)**	**30.36 (CI 25.82 - 35.70)**
Pacific Islander	**4.68 (CI 2.93 - 7.48)**	**2.58 (CI 1.24 - 5.38)**
Gurkha	**0.16 (CI 0.91 - 0.03)**	**0.00**
Other	**0.74 (NS)**	**0.68 (NS)**

Table 2. Relative Incidence after Withdrawal of Normals and Within Normal Limits; CI at 95%

The results by Severity Code were then analysed against ethnic groupings. The African Americans had significantly more severe injuries as represented in Figure I. When analysed by the means of severity score the African Americans have a much higher mean score, 5.39 (SD 1.994) versus 4.24 (SD 1.767) of Caucasians. When analysed by Independent Samples Test and t-test for Equality of Means, the significance between these groups is 0.0001. There was no statistical difference for Pacific Islanders.

When age is compared against ethnicity, the Caucasians have the broadest range, from 18 – 60 years. The African Americans and Pacific Islanders have much narrower age ranges as detailed in Figure 2, illustrating the bunching of African Americans attending the CIC around their twenties. The Pacific Islanders are more uniformly spread, but far fewer in number. The age of attendance of Caucasians and African American was not statistically different with the mean for Caucasians of 26.68 (SD 7.735) and for African Americans of 26.05 (SD 3.428). A graphical representation of age against ethnicity is at Figure 3.

Category	Frequency	Percent	Cumulative Percent
Normal	31	10.0	10.0
Within Normal Limits	20	6.4	16.4
Lower Limit of Normal	24	7.7	24.1
Mild	64	20.6	44.7
Mild / Moderate	64	20.6	65.3
Moderate	46	14.8	80.1
Moderate / Severe	37	11.9	92.0
Severe	17	5.5	97.4
Very Severe	8	2.6	100
Total	311	100	

Table 3. Analysis of Severity Codes

When examining the relative incidence of referral, adjusted by excluding those with Normal and Within Normal Limits on INM testing, the RI for African Americans was 30.36, for Pacific Islanders 2.58 and Gurkhas 0.00. When examining severity of the condition against ethnicity this was only true for African Americans against Caucasians. There was no statistical correlation between Pacific Islander ethnicity and severity score, and there was only one Gurkha, who recorded a normal outcome.

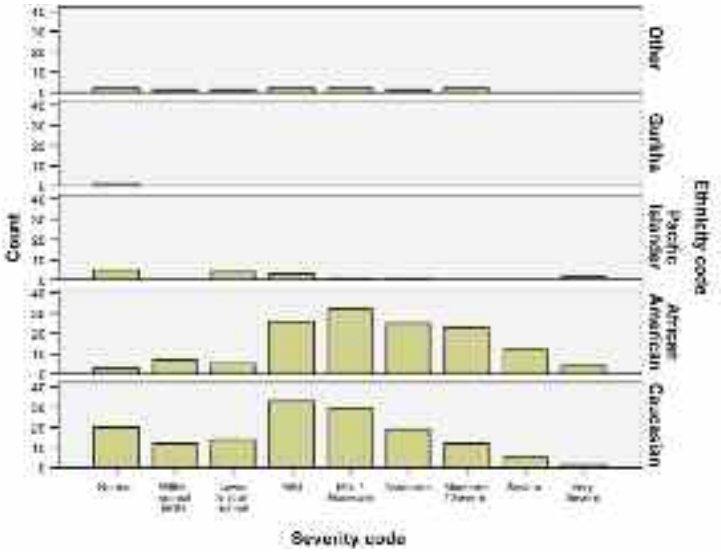

Figure 1. Ethnicity Against Severity

Discussion

This study was powered to determine a relationship between ethnicity and severity for those referred for peripheral cold injury. Unlike previous American studies it included those undergoing basic training as well as trained soldiers.

Analysis at INM showed that 16.4% were graded Normal or Within Normal Limits, soldiers who had experienced the symptoms of CWI but in the minimum period between injury and assessment had recovered physiological function. The African Americans had significantly more serious injury on assessment than the Caucasians.

This study found no correlation between age and ethnicity or between age and severity. The mean age was virtually identical between the four largest ethnic groups, but with a much larger SD for Caucasians. The Caucasians appeared in a preponderance at the youngest ages and in the upper segments, above age 33. This finding was to have been expected as Commonwealth soldiers tend to be older on recruitment, but few so far have had the opportunity to pursue full careers. When comparing age against severity, the plot is widely and uniformly scattered.

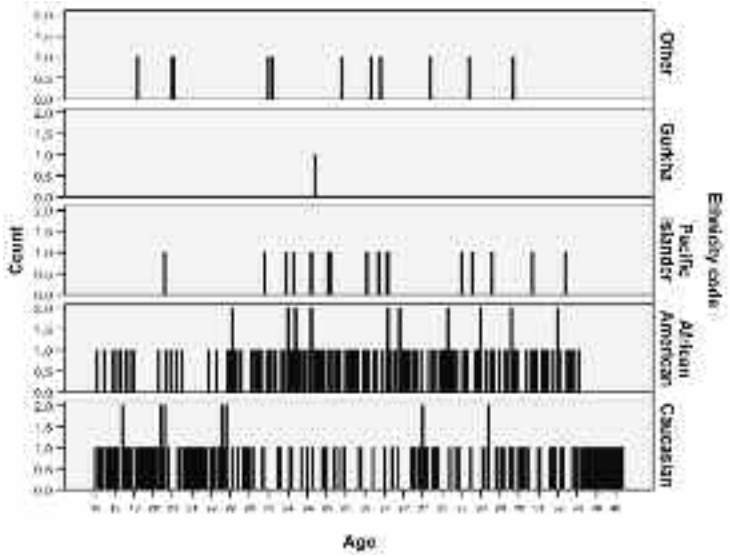

Figure 2. Ethnic Origin Against Age

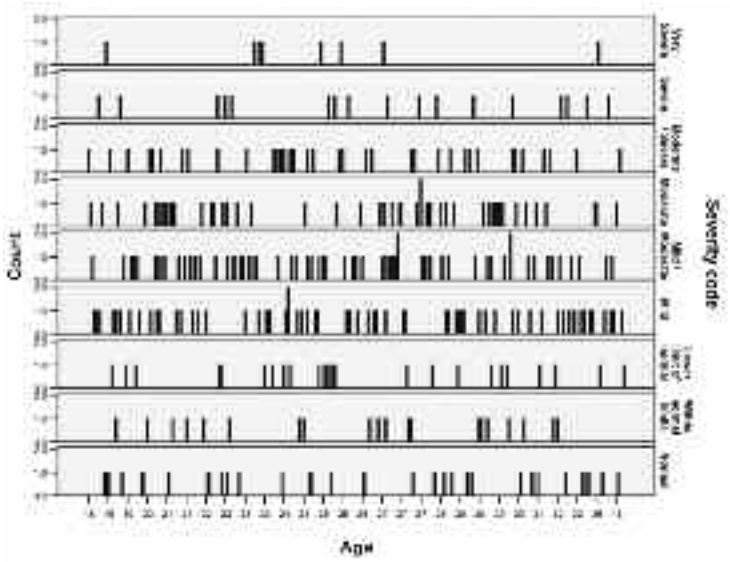

Figure 3. Age against Severity Score

The modern African American soldier in the British Army follows a similar path to his Caucasian peer. They undertake similar training and operational tasks, and are similarly equipped, clothed, accommodated and fed. The conclusion is that the much higher RI is a consequence of ethnicity delivering a physiological effect. The relative incidence of Pacific Islanders after removing those graded as Normal or Within Normal Limits was 2.58 (CI 1.24, 5.38) against Caucasians, a much lower rate than for African-Americans.

Conclusion

The relative incidence of peripheral cold injury for African Americans is 30.3 times, and that of Pacific Islanders 2.6 times, that of Caucasians, while Gurkhas are protected. The severity of the condition was significantly greater in African Americans than Caucasians. This paper reiterates that African Americans are at increased risk, but for the first time shows that Pacific Islanders are also at risk, but to a lesser extent.

Most of the cases were at junior rank and whilst training. For the Army to be regarded as a fair employer it must ensure that suitable clothing and equipment is well researched, tested, issued and allowed to be used. Whether specialist cold weather clothing is issued to all or only to certain high risk groups will be a command decision. Making recommendations on entry into the Army in order to protect vulnerable recruits in an era of equality will be particularly challenging.

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