British Army recruits with low serum vitamin D take longer to recover from stress fractures

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ABSTRACT

Background Recruits undergoing military training experience a particularly high incidence of stress fractures. The role of combined calcium and vitamin D (25-OHD) deficiency and subsequent supplementation has been well described in the literature, but the role of 25-OHD deficiency alone is less well understood, particularly its influence on recovery once a stress fracture has been incurred.

Methods Retrospective data of recruits who had incurred stress fractures were collected (n=37). Independent-samples t-tests were conducted in Microsoft Excel to investigate the association between serum-25 OHD and the time taken to recover.

Results Significant differences ($p<0.05$) were found in the mean time taken to recover from stress fractures when participants were grouped according to serum 25-OHD level. Sufficient levels of serum 25-OHD (>50 nmol/L) at the time of injury resulted in shorter recovery times than all other groups.

Conclusion The study demonstrated an association between serum 25-OHD level and the time taken to recover from a stress fracture. The sample population of this study was too small to contribute to the discussion about whether a minimum serum 25-OHD status should be met before entering British Army training, but a larger prospective study should be able to provide the data required for a cost benefit analysis to be conducted and a decision made.

Key messages

- Vitamin D deficiency lengthens the time British Army recruits take to recover from stress fractures.
- The measurement and potential supplimentation of vitamin D before commencement of training could reduce the net cost of training recruits.

INTRODUCTION

Stress fractures are overuse injuries provoked by commencement of, or an increase in, high frequency repetitive activity. They most commonly occur in the weight-bearing bones of the legs when they have not had sufficient time to adapt to a new exercise regimen.[1]

Military training and stress fractures

Soldiers have long suffered from stress fractures; indeed, they were first described as 'march fractures' following observations of injuries to Prussian soldiers in the 19th century, 40 years before the advent of radiography.[2]

Military training provides model conditions for stress fractures to develop as it comprises strenuous, regular exercise that is conducted in boots while carrying weight. In the initial training of recruits, the onset of this activity is relatively sudden. Furthermore, a high proportion of soldiers are recruited from deprived areas where inactivity and poor nutrition are commonplace,[3] potentially exacerbating the incidence and effects of stress fracture. A prospective study of 295 male Israeli Army recruits found a 31% incidence of stress fractures,[4] and although findings this extreme are not typical in the literature, there is a consensus that military training is a significant risk factor for stress fracture.[5]

Vitamin D and stress fractures

Vitamin D (25-OHD) insufficiency has been associated with an increased incidence in bone fatigue and stress fractures,[4 6] and the American Orthopaedic Foot & Ankle Society (AOFAS) observes that 'critical review of the available evidence indicates that a relationship exists between sufficient vitamin D status and stress fractures'.[7]

Various studies have found an association between combined deficiencies in calcium and 25-OHD and the development of stress fractures in young soldiers undergoing training.[8] Others have found that prophylactic supplementation of both calcium and 25-OHD decreased the incidence of stress fractures once training was started.[9] Far less research has been conducted into the value of 25-OHD status alone and its roles as either a risk factor for a stress fracture occurring or a prognostic indicator of recovery have not been fully described.

This study investigated the association between serum 25-OHD status and the time taken by British Army recruits to recover from stress fractures, measured by recruits' absence from training.

METHOD

Data for 37 British Army recruits (21 (57%) male) who suffered a stress fracture in a 3-year period (Summer 2010–Summer 2013) were collected from the Physiotherapy Department at an Army Training Regiment. Serum 25-OHD level was measured at the time of injury. 91.9% of recruits were white (n=34), 5.4% were black African (n=2) and 2.7% were black Caribbean (n=1). 56.8% of recruits were male (n=21).

The most frequently recorded activities when stress fracture was incurred were endurance runs in boots (24.3%), field exercise (21.6%), endurance

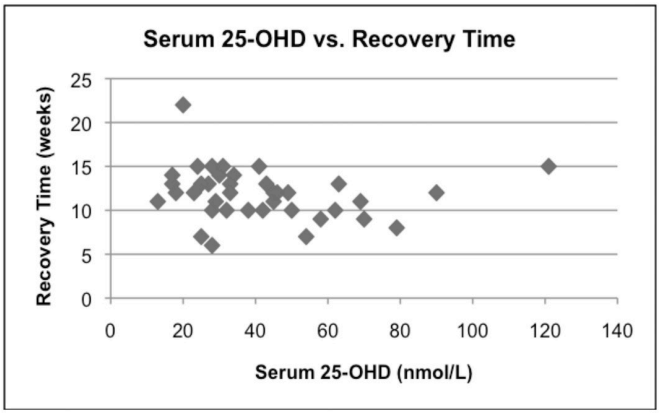

Figure 1 Individual associations of time taken to recover from stress fracture and serum 25-OHD level

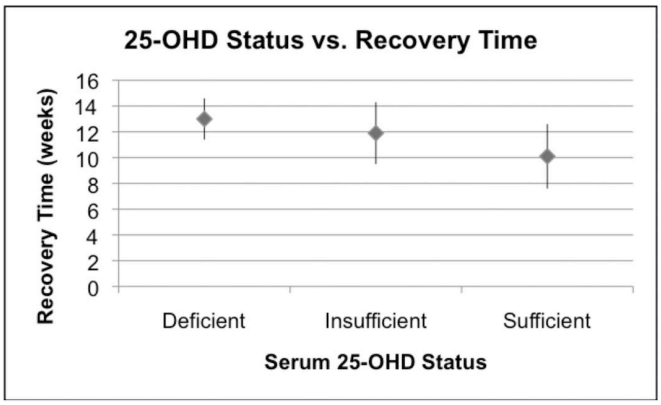

Figure 2 Association of time taken to recover from stress fracture when grouped according to serum 25-OHD status

runs in shoes (18.9%) and general physical training (16.2%). Other recorded activities were drill (8.1%), assault course (5.4%), adventurous training (2.7%) and the personal fitness assessment (2.7%). Also available was stage of training (week of injury), site of injury, outcome, time taken to recover (weeks in rehab) and 2.4 km run time (one of the British Army's standard fitness tests). Data for recruits without stress fractures were not available.

Analysis was conducted using Microsoft Excel, V.12.3.6 (Redmond, Washington, USA) with a view to determine whether there was an association of 25-OHD status and the duration of absence from training, defined as the time taken to recover. On recovery, soldiers rejoined the training programme at the point at which they departed. The data of those recruits that left the Army due to the severity of their injury were not included.

Ethical approval was granted by St George's Hospital Medical School and the Senior Medical Officer at ATR Pirbright. Patient data were anonymised before it was passed to the investigator.

RESULTS

An initial comparison of serum 25-OHD level and recovery time demonstrated a mean recovery time of 11.7 weeks (figure 1).

The National Institute of Clinical Excellence (NICE) advises that there is consensus that serum 25-OHD levels below 25 nmol/L are considered deficient, but there is currently no optimal target level.[10] The US Institute of Medicine has further determined that serum 25-OHD levels required for good bone health in most individuals is 50 nmol/L,[11] and recommends additional breakdown of vitamin D status into three groups of deficiency (25-OHD<50 nmol/L), insufficiency (25–50 nmol/L) and sufficiency (>50 nmol/L).[12]

When this study's data were trichotomised according to the US Institute of Medicine's classification (table 1), a trend of decreasing recovery time with decreasing serum 25-OHD level was evident (figure 2), with a 15.1% difference in recovery time between sufficiency and insufficiency, an 8.5% difference between insufficiency and deficiency and a 22.3% difference between deficiency and sufficiency (table 2).

Independent-samples t-tests were conducted to compare the sufficient group with the insufficient and deficient groups and those with any degree of insufficiency (25-OHD<50 nmol/L). Most notably, this demonstrated a statistically significant 17.8% difference in recovery time between recruits with serum 25-OHD levels above and below 50 nmol/L (sufficiency vs any insufficiency) (table 2).

There was no evidence of a difference in recovery time found between the insufficient and deficient groups. This is particularly interesting, as it reinforces opinions in the literature that a subclinical deficiency may exist at a higher serum 25-OHD value than is currently recommended.[12 13]

No statistical difference in the time taken to recover was found between groups when patients were divided by sex, site of injury or the stage of training the patient had reached when the injury was incurred.

DISCUSSION

Results indicated that serum 25-OHD level was associated with lower limb stress fractures, which is consistent with the findings of previous research.[6 8 9] To date, limited research has focused on recovery time as a dependent outcome and this study has gone some way to describe that once a stress fracture has developed, serum 25-OHD status significantly influences recovery.

Trichotomising the participants according to the US Institute of Medicine's classification of 25-OHD status provided an alignment of the study's findings with the guidance given to healthcare professionals. The resultant differences in recovery times between groups reinforced the value of an arbitrated distinction. The 22.3% difference in mean recovery time between those subjects who were 25-OHD sufficient and deficient implies that bone recovery is inhibited by low 25-OHD levels and recovery time from stress fractures could therefore be improved by

Table 1 Effect of serum 25-OHD on time taken to recover from stress fractures

25-OHD status	n	Mean serum 25-OHD (nmol/L)	Mean recovery time (weeks)
Deficient (<25 nmol/L)	5	18.8 (± 4.6)	13.0 (± 1.6)
Insufficient (25–50 nmol/L)	21	34.4 (± 8.4)	11.9 (± 2.4)
Sufficient (>50 nmol/L)	11	70.0 (± 20.6)	10.1 (± 2.5)

Table 2 Sufficient serum 25-OHD vs other serum 25-OHD status groups

Sufficient serum 25-OHD vs other groups (independent-samples t-tests)				
	Mean difference (%)	t	df	P value
vs Deficient	22.3	2.81	12	0.015
vs Insufficient	15.1	1.98	20	0.062
vs Any insufficiency (insufficient+deficient)	17.8	2.31	17	0.034

achieving and maintaining a serum concentration >50 nmol/L. This could be measured by ascertaining potential recruits' serum vitamin D status at an early stage in the recruitment process, providing an opportunity for supplementation before commencement of training.

Data of recruits' socioeconomic status, activity levels prior to the commencement of training and serum 25-OHD status before injury were not available for this study. This information, alongside compliance with standardised management of stress fractures and criteria for return to training would assist in quantitate analysis of the effect of 25-OHD deficiency and should be included in future studies.

CONCLUSION

This study demonstrated an association between serum 25-OHD status and the time taken by British Army recruits to recover from stress fractures sustained during initial training, specifically that a serum 25-OHD level of less than 50 nmol/L resulted in a longer period of recovery before re-entering the training programme.

The British Army has imposed minimum values for a number of physical criteria that need to be satisfied before a potential recruit is allowed to enter initial training and subsequently move from a training unit to the Field Army. These currently include, among others, fitness tests, body mass index status and whether the recruit is free from injury. With sufficient evidence that military training could multiply the baseline risk of stress fractures in recruits, ensuring that vitamin D insufficiency is minimised appears to be a logical ambition and one that could be achieved by imposing a minimum serum 25-OHD level threshold for entry to initial training.

The study was limited by its small sample size and the fact that serum 25-OHD levels were not measured in recruits who did not develop stress fractures, removing the possibility of a control group. A larger study should next be conducted to determine whether routine screening is beneficial and cost effective before policy can be influenced.

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