Lower limb stress fractures in military training

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Abstract

This article describes stress fractures that are seen in military training, and reviews the relevant literature. The information is vital for medical personnel who work with the United Kingdom (UK) Armed Forces, particularly those working in training establishments. The author suggests areas for further research and discusses some of the issues in current UK Armed Forces training.

Introduction

By way of example, Royal Marines (RM) training in the UK Armed Forces is conducted at the Commando Training Centre in Lympstone (CTC Lympstone), Devon. At fortnightly intervals throughout the year, except during military leave periods, 55-60 recruits join the RM training programme. Basic training spans 32 weeks, the longest military basic training course in the western world, and the average recruit takes approximately 37 weeks to complete the syllabus (1, 2). Training becomes progressively more arduous over this period, culminating in the commando tests: a thirty-mile cross-country run; a nine-mile run on roads; a seven-mile cross-country run which includes negotiating water and tunnels; an aerial assault course; and a final week-long exercise over difficult and varied terrain.

RM training and recruit training is known to cause sport-related injuries (3-5). Recruits are expected to be fit and to participate in sport; many of the recruits will play contact sports including football and rugby, which have been shown to cause injuries (6, 7). A significant proportion of lower limb injuries in sport are caused by damage to the knee. In the military, the rates of knee injury are suggested to be as high as 50% (8). This may be due to recruits participating in certain sports that put great rotational and deceleration or acceleration forces on the knee. The reported injury rate of the Anterior Cruciate Ligament (ACL) in a civilian setting may vary from <1% to up to 5% dependent upon gender, preparation and ability (9, 10); these figures are similar to those found in military studies (11-13). There is extensive civilian and military literature on knee injuries; this, coupled with the fact that many of these may be related to playing sport rather than to direct military training, places these injuries outside the scope of this review.

With regards to traditional training injuries, studies have demonstrated that lower limb injuries and musculoskeletal injuries predominate in military recruits (14). Injuries such as tibial stress fractures (15), chronic compartment syndrome (16), and other injuries including ankle sprains (17) are seen. Almeida *et al*. demonstrated that, among United States (US) marines, ankle injuries were the second most commonly reported injury (18), and Waterman *et al*. demonstrated that over half of US recruits sustained lower limb injuries, with 11% suffering from ankle sprains (19). While any over-use, or acute lower limb injury, can occur in military training, this literature review will focus on lower limb stress fractures, because these injuries have a significant impact on military training.

Stress fractures

Stress fractures are recognised in personnel undergoing military training and in athletes, with the first reported case being identified in 1855 by Breithaupt (20), and the first imaging of a stress fracture recorded by Stechow in 1897 (21). Stress fractures, also commonly referred to as fatigue fractures, are sub-acute injuries that develop as a result of repetitive over-use of a limb. They are the result of excessive use of a limb over time: the intrinsic ability of bone to repair itself is overwhelmed by the frequency of use (20).

The most commonly held theory on aetiology is that the process of remodelling is accelerated and that osteoclastic activity exceeds osteoblastic activity for some weeks. The constant use and overloading experienced in a military basic training environment could extenuate this process, leading to micro-fractures, stress reactions and eventually stress fractures (22). The incidence of sustained stress fractures in military recruits can be as high as 12% (23), compared with a rate of around 21% in elite athletes (24), and 1% in the general population (25).

Studies have estimated the annual incidence of stress fractures among groups of athletes and military recruits to be between 5-30%. With the multi-factorial aetiology of stress fractures it is difficult to speculate on the exact cause of these fractures (26). Military studies may underestimate the incidence, due to a reluctance of recruits to present to medical centres, which may explain a lower than expected incidence in military studies compared to studies on athletes (23).

Trone *et al*. suggested that recruits who sustain a stress fracture during basic training are over four times more likely to be discharged from training programmes; these injuries can be responsible for a significant proportion of the attrition rates seen in military training, with consequent morbidity amongst recruits and a drain on resources for the military (27).

Furthermore, recruits who suffer a stress fracture during basic training are, after initial rehabilitation, at higher risk of sustaining stress fractures during subsequent training (10.6% incidence within one year of injury vs. 1.7% in injury-free recruits), thereby increasing working days lost to injury, with the accompanying impact on operational capability (28).

Currently, little is known about the length of time required to rehabilitate recruits from stress fractures and return them to their pre-injury level of physical activity; previous studies have only looked at the return to sport in athletes in a general population, where rehabilitation is not as controlled as within a military population (29).

'A Royal Marine's Training', a study undertaken by Ross and Allsopp, looked at stress fracture rates in recruits undergoing basic training at CTC Lympstone, both before and after the implementation of the Revised Common Recruit Syllabus (RCRS) (30). This syllabus was commissioned to optimise the training programme with respect to reducing injury rates. It demonstrated a statistically significant reduction in stress fracture rates between the more physiologically progressive RCRS syllabus (3.8%) and the original training programme (7%). In this study, 30% of patients in the new syllabus were still in training when data collection was completed.

When treating stress fractures Talbot *et al*. advocate a high clinical index of suspicion and early referral for MRI to enable prompt diagnosis among at-risk populations for stress fractures (31). They recognised that radiographs do not usually contain positive signs associated with stress fractures until two weeks after the onset of symptoms (32). The Director of Defence Rehabilitation (DDR) Best Practice Guideline supports the approach by Talbot on the management of exertional leg pain by recommending the use of MRI, rather than x-ray, as first line imaging when the clinical suspicion of stress fracture is high (33). This is because x-ray is not as sensitive as MRI in detecting stress fractures (34, 35).

Metatarsal stress fractures

In athletic and military populations, the metatarsal bones, in particular the third metatarsal, sustain the greatest number of injuries (23, 35, 36). Previous research suggests that the third metatarsal is the most common site for fracture, because of its increased ligament support, which causes relative resistance to movement and thereby increases the stress forces placed upon this bone (37, 38).

Dixon *et al*. undertook a study on RM recruits, both with and without a history of third metatarsal stress fractures, and discovered significant differences in dynamic biomechanical variables of the forefoot (39). They concluded that successful future intervention to reduce the incidence of this injury would likely focus on this area.

Garcia *et al*. demonstrated that a majority of metatarsal stress fractures occur in the first three weeks of military training; they postulated that one reason for this is that, during the early phase of bone remodelling, excessive resorption temporarily decreases the ability of the bone to withstand force (40, 41).

Talar stress fractures

Although stress fractures of the talus are a rare cause of lower limb injury, they have been regularly identified in athletes and military recruits since first being described by McGlone in 1965 (43). This may be due to military recruits and athletes being exposed to a sudden increase in physical training and participating in activities that cause repetitive axial loading (44). Talar stress fractures are often reported as case studies and illustrate the difficulties associated with diagnosing these types of fractures. This is mainly due to the clinical variability of symptoms, which include point tenderness, ankle effusion and soft tissue swelling (44). Prolonged healing times have often been associated with injuries to the talus, which can cause chronic pain and necrosis (45).

Sormaala *et al*. conducted a retrospective study at the Central Military Hospital in Helsinki, Finland, looking at MRI referrals for exercise-induced ankle or foot pain over an eight-year period (45). They detected 56 talar injuries and found that 44 had additional stress fractures in other tarsal bones, primarily the navicular and the calcaneus. In this study, many recruits had reported taking time out of military training due to prolonged, exercise-induced ankle pain. The authors conclude that a prompt MRI should be carried out in recruits with exercise-induced ankle pain, to ensure early diagnosis and correct treatment, which in turn helps to avoid healing complications.

Tibial stress fractures
A study by Beck showed that tibial stress injuries may be a consequence of repetitive strain which can occur during chronic-weight bearing activities, such as running (46). When new recruits join training programmes and running becomes a primary physical training activity, the majority of stress fractures occur in the tibia, and are a common cause of compartment syndrome (47). There is a higher incidence of low-risk posteromedial tibial fractures, compared to anteromedial tibial fractures, which have a higher chance of non-union (46). It is important that exercise-induced pain in the lower leg is investigated to rule out severe complications of these types of stress fracture. Behrens *et al*. recommend that patients with tibial stress fractures should stop all high-impact activities until they are asymptomatic when walking (48). For military recruits, this may significantly delay their training and be an added cost to the program.

Femoral stress fractures
Femoral stress fractures are uncommon (31,40,41), but a recent study undertaken on recruits based in Northallerton documents that femoral fractures constitute 8% of all diagnosed stress fractures (31). The peak presentation time of femoral stress fractures has been debated; it has been variously documented as occurring at weeks 13-16 of training (31), and weeks 4-7 of training (42). Femoral stress fractures, though less common than fractures at other lower limb locations, represent a more severe complication of training (31). Unprotected, undisplaced fractures can lead to displaced femoral neck fractures, which carry a 63% complication rate even with optimum treatment (42).

Giladi *et al*. showed that 10.6% of recruits who suffer a femoral stress fracture may sustain recurrent stress fractures within one year (49). This indicates a need for appropriate rehabilitation and close follow-up for recruits sustaining this type of fracture, in order to prevent other stress fractures developing.

It is recognised that prevention of stress fractures is difficult due to the multifactorial nature of the injury (41). The fundamental aspects of treatment remain early diagnosis, early identification of symptoms and a sufficiently long pause in training to allow healing to occur (41,42,49,50).

Despite awareness of the injury and its relative low incidence compared to similar population groups, stress fractures represent a significant burden in RM training (30). Stress fractures account for approximately 814 weeks of lost recruit rehabilitation time per year, at an estimated cost of 1.2 million pounds per annum (1).

Summary
Lower limb stress fractures are common in military training, and have been demonstrated to have a significant financial impact. Further research into the incidence of lower limb injury in military training, and immediate post-training employment, are required to ascertain whether these injuries continue to cause problems after basic training. Such research should ideally be conducted as a prospective cohort study to ensure accurate epidemiological data.

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Recent changes in hypoxia training at the Royal Air Force Centre of Aviation Medicine

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Abstract

Hypoxia training at the Royal Air Force Centre of Aviation Medicine (RAF CAM) has traditionally involved the use of a hypobaric chamber to induce hypoxia. While giving the student experience of both hypoxia and decompression, hypobaric chamber training is not without risks such as decompression sickness and barotrauma. This article describes the new system for hypoxia training known as Scenario-Based Hypoxia Training (SBHT), which involves the subject sitting in an aircraft simulator and wearing a mask linked by hose to a Reduced Oxygen Breathing Device (ROBD). The occupational requirements to be declared fit for this new training method are also discussed.

Hypoxia training

Royal Navy Medical Officers (RN MOs) undertaking aircrew medicals or attending aviation medicine training at Royal Air Force Centre of Aviation Medicine (RAF CAM), should be aware that the method of hypoxia training has changed fundamentally in the last three years.

Senior MOs may recall receiving a hypobaric chamber experience as part of their aviation medicine training; this used to be the way that all aircrew did their initial and refresher hypoxia training. In hypobaric chamber training, while the chamber occupants breathe 100% oxygen through a mask, the air pressure in the chamber is reduced

Fig 1. Scenario-Based Hypoxia Training (SBHT) in an aircraft simulator, wearing a mask linked by hose to a Reduced Oxygen Breathing Device (ROBD) (Photograph by SAC Runciman RAF).