

Musculoskeletal Injuries in British Army Recruits: A Retrospective Study of Incidence and Training Outcome in Different Infantry Regiments Over Five Consecutive Training Years

Heagerty RDH^{1#}, Sharma J^{1,2,3#} and Clayton JC¹

[#]Equally contributed and joint first authors.

¹Defence Primary Healthcare, Primary Care Rehabilitation Facility, Infantry Training Centre Catterick, North Yorkshire, UK

²School of Health and Social Care, Teesside University, UK

³251 Medical Squadron 3 Medical Regiment, UK

*Corresponding author: Dr. Jagannath Sharma PhD MCSP RAMC, Defence Primary Healthcare, Medical Centre & Rehabilitation Department, Infantry Training Centre Catterick Garrison, DL9 3PS UK, Tel: 01748-872916; E-mail: jagannath.sharma706@mod.uk; jagannath.sharma13@gmail.com

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Abstract

Background: Musculoskeletal training injuries represent a considerable socio economic burden with far reaching implications on organisational effectiveness. Injury data analysis is fundamental to understanding the magnitude of the problem and underpins the subsequent design and delivery of targeted prevention strategies.

Aim: To evaluate five years inter-regimental musculoskeletal injury patterns and training outcomes in British infantry recruits.

Methods: This was a descriptive retrospective observational study of 4777 MSKI reported from a total of 12501 British Infantry recruits over five consecutive training years (1st April 2012-31st March 2017). The observed cohorts comprised of recruits from the Parachute Regiment (n=1910), Line Infantry (n=7799), Guards (n=1834) and the Gurkha Regiment (n=958). The physiotherapy Department collected the injury data throughout consecutive phase 1 and phase 2 training, the Combat Infantryman Course (CIC).

Results: The five year cumulative incidence varied between the individual training regiments; 66.49% (95% CI: 64.39-68.62), 38.17% (95% CI: 35.97-40.42) 33.29% (95% CI: 32.22-34.31) and 22.03% (95% CI: 19.42-24.65) for Parachute, Guards, Line, and Gurkha respectively. Overuse injuries were the most frequently observed sub-classification whilst the most common site for all types of injury was the knee. Significant difference was found ($p < 0.01$) in the incidence of all MSKI between phases 1 (<week 13) and 2 (>week 13). 42.1% of the total injuries accounted for within the first eight weeks of training. Training outcomes; recruits successfully completing training at the first attempt were found to be significantly different ($p < 0.01$); 37.0% (Parachute), 53.1% (Guards), 64.6% (Line) and 98.42% (Gurkha).

Conclusions: The wide range in the incidence of MSKI and training outcomes across the four Infantry training Regiments, suggests that there is a requirement to thoroughly investigate the content and delivery of training within the CIC as well as the impact of the introduction of an integrated injury prevention strategy-Project OMEGA.

Keywords: Muscular-skeletal injury; Military recruit training; Financial burden; Injury prevention

Key Messages

MSKI are a globally recognised bi-product of arduous military training and represent a considerable burden to military budgets, training efficiency and an overall threat to organisational resources and effectiveness.

The aim of this paper is to contribute to a better understanding of regimental specific injury patterns within British Infantry recruits.

This paper specifically serves to describe the rate and characteristics of MSK injuries within the different training regiments at ITC in order

to help future prioritisation of organisational efforts both reduce MSKI and mitigate their far reaching implications.

Health Care Governance requires a commitment to deliver continuous quality improvements initiatives such as the Injury Prevention strategy-Project OMEGA.

Introduction

The Infantry Training Centre (ITC) Catterick is the only combined Phase 1 and Phase 2 recruit training establishment in the British Army [1-4]. Lasting over a minimum of twenty six weeks the Combat Infantryman's Course (CIC), recognised as the most physically challenging of all initial British military courses [5] is delivered to as many as 4,000 recruits per year [2,3].

Eight training companies sit under the command of two Infantry Training Battalions. The first Infantry Training Battalion (1ITB) consists of standard (Line) Infantry regiments with the second Infantry Training Battalion (2ITB) responsible for the training of recruits in the Guards, Parachute and Gurkha Regiments. The syllabus consists of both basic military training as well as regimental specific skills [6,7]. The Guards Company, for example has a specific focus on foot drill whilst the Parachute Company focuses on preparing recruits to pass the physically and mentally demanding airborne selection course, "P Company" [3,6]. Lasting thirty-nine weeks, Gurkha recruits undergo the longest training of all regiments. This is due to the syllabus including three bespoke additional packages; consisting of language and cultural education as well as tactical close combat and martial arts training [1,4,6,7]. Irrespective of specific regimental requirements all training teams are required to train and develop civilian volunteers into Class Three Infanter's suitably prepared to join the British Field Army [3].

Strategic leadership and management of the training syllabus are co-ordinated by the Support Battalion Head Quarters. The physical development programme is delivered by the All Arms Physical Training Instructors (AAPT) under the management of the Royal Army Physical Training Corps (RAPTC). Medical, Physiotherapy and Rehabilitation provision falls under the command of Officers of the Royal Army Medical Corps (RAMC) and is delivered within the governance of Defence Primary Healthcare (DPHC) [7].

Governance

Governance is a key component of delivering education and training to young adults and as such the Ministry of Defence (MoD) firmly embraces the moral and professional responsibility [2,3,7]. The ITC is subject to regular visits and inspections with pastoral and welfare provision assessed every two years by the Office for Standards in Education, Children's Services and Skills (OFSTED), whilst Medical management as well as delivery of the rehabilitation care pathway is subject to biennial Health Care Governance Inspections. Collection and analysis of injury surveillance is fundamental to service evaluation, refinement of clinical delivery and a basic component of Health Care Governance [2,3]. The MoD is highly committed to ongoing service evaluation and as such quality improvement is an imperative reflected in the Commanding Officers Training Directive [8].

Incidence

Training related injuries are reported to range widely not just within the British Army but also across international military organisations; from 10% [6], 20% [9], 33.1% [10], 39.6% [11], 38.2% [3], 50.7% [12], 48% [1], 59% [13], 59.7% [14] to as much as 86% [6]. The incidence, specifically in training establishments, has understandably promoted investigation in to causation and prevention which in turn has served as a basis for further understanding of what constitutes an effective prevention strategy [1-4,15-18].

Financial implications

The financial burden of MSKI to military budgets is well documented globally [2,3,10,19,20]. Amongst United States Marine Corps (USMC) recruits, stress fractures alone represent estimated costs of \$16.5 million per year with estimated annual cost related to all training injuries of \$100 million (21). Recognised as the leading cause

of medical discharge [MD] alone from both military training and the Field Army they represent an estimated cost to the British Army of £1.02 billion over fifteen years [21-23]. 9.1% of MD has been attributed to training MSKI within the ITC [3] with as much as 30-50% of disability cases with associated compensation costs of up to \$1.5 billion have been attributed to MSKI in the US military [24]. Average medical costs per training related MSKI have been reported by Swiss military insurance as 1,750 (CHF) or 1,925 US \$ equating to 6.9 million CHF or \$7.6 m for 25,000 army recruits per year [25]. In addition, the complex bio-psycho-social implications of these injuries inevitably mean that the true financial cost is likely to be underestimated. Moreover, the increased strain on the medical services, loss of days in training due to temporary downgrade, placement on light duties and potential risk of subsequent medical discharge presents an on-going costly challenge [1-7]. Attrition due to MSKI within the training environment is understood to represent a considerable financial burden and ultimately to contribute to compromised operational capability [1,3,4,11-15]. Consequently, MSKI are considered as a considerable threat to delivery of the CIC and therefore the effectiveness and productivity of the ITC, which in turn potentially impacts on the supply of trained Infanter's to the British Army [1-4,26].

Injury prevention

Injury prevention is a systematic approach which in keeping with the "sequence of prevention of injuries" model [4,27] involves four vital steps fundamental to the design of effective strategies of mitigation. The initial phase is to identify and then quantify the impact of injury, thereby confirming whether the problem is indeed "actual or perceived". Baseline measures are fundamental in order to establish a start point from which assessment of the potential success or failures of any future intervention may be referenced. Military institutions rely heavily upon budgets, determined by policy-makers who require evidence as to the scale of confirmed threats to their organisational effectiveness which in turn justifies the proportional allocation of resources to mitigate [1,4,28-30].

Potentially career and therefore life changing events, in the physical domain but seen more increasingly form a psycho-socio perspective; MSKI can have significant and far reaching impact on the individuals affected [1,4,31]. Analysing and interpreting meaningful data is a prerequisite for identifying injury patterns and determining the direction of subsequent injury prevention strategies [28,30,32]. Despite thorough appreciation of the far reaching impact of MSKI on military communities globally there is a relative paucity of baseline inter-regimental epidemiological data available from which informed changes to training programmes can be made. Specifically, only two papers have been previously published from this Institution. An initial paper Sharma et al. [6] describing MSKI patterns at the ITC observed significant disparity (10%-86%) in incidence and first time pass out rates (38%-98%) between individual training regiments. The second paper based upon four year data (2012-2016) found injury incidence (24.6%-66.2%) with first time pass out rates (38.6%-98.8%) [7]. These papers both firmly recommended the need for continual analysis of injury trends in order to introduce targeted regimental specific injury prevention strategies.

Aim

The aim of this paper is to investigate a five year retrospective inter-regimental injury incidence and training outcomes. It is intended that this paper will contribute significantly to the body of evidence from

which strategic injury prevention and physical performance strategies may be designed and delivered.

Method

A retrospective observational study design was applied in order to investigate the inter-regimental injury patterns at ITC for five consecutive training years (2012-2017). A complete training year runs between the 1st April and 31st March. Consistent with the previously published four year inter-regimental paper this study followed the same procedure and methodology of injury data collection [2,3,7].

Recruits reporting an MSKI presented to the co-located ITC Medical Centre, where they were assessed and triaged by Combat Medical Technicians (CMT) prior to referral to a duty Medical Officer who then determined the requirement for physiotherapy. If considered necessary, the Medical Officer referred the injured recruit to the Primary Care Rehabilitation Facility (PCRF) where an appointment was offered within seventy-two hours.

The PCRF at ITC maintains a password protected data base in which MSKI were entered weekly into the standardised departmental

injury database by the Administrative Assistant. The content of the database is presented in previous papers [2,3]. The Clinical Specialist Physiotherapist then reviewed and sifted the data for all training regiments. Each new referral was considered as an initial episode whilst repeat injuries re-presenting within four weeks of original presentation recorded as an original episode of care. In keeping with the method applied in previous studies [2,3,6,7], in the interest of accuracy and to minimise error all data sets were checked independently by three senior members of the clinical management team prior to application of statistical analysis.

A total of 4777 MSKI from an inflow of 12501 recruits presented to the PCRF during the five year period; 1st April 2012 to 31st March 2016. The total number of MSKI did not include those reported by permanent training staff or Reservists. Each recruit who presented with a new MSKI was recorded as a new episode of care and information collected according to the injury register database spread sheet.

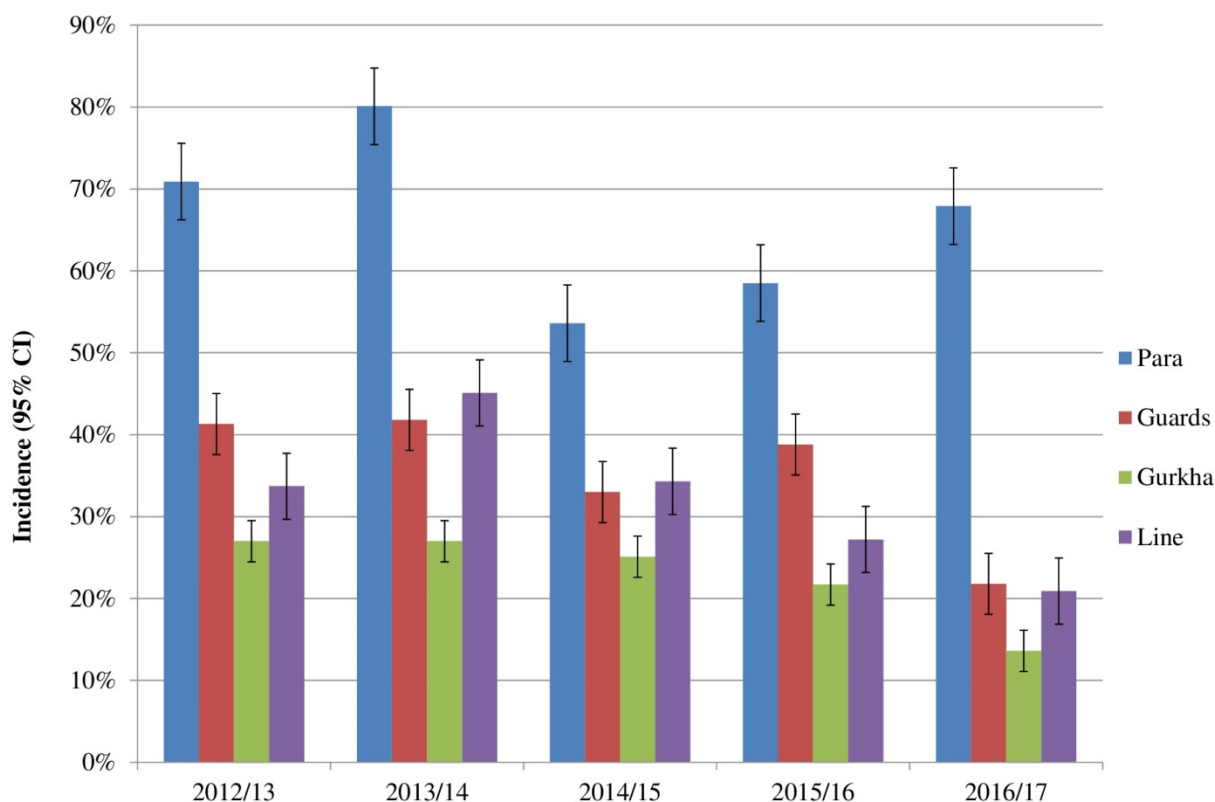


Figure 1: MSK injury incidence with 95% Confidence Interval (CI) for each CIC Infantry Regiments during training year 2012-2017.

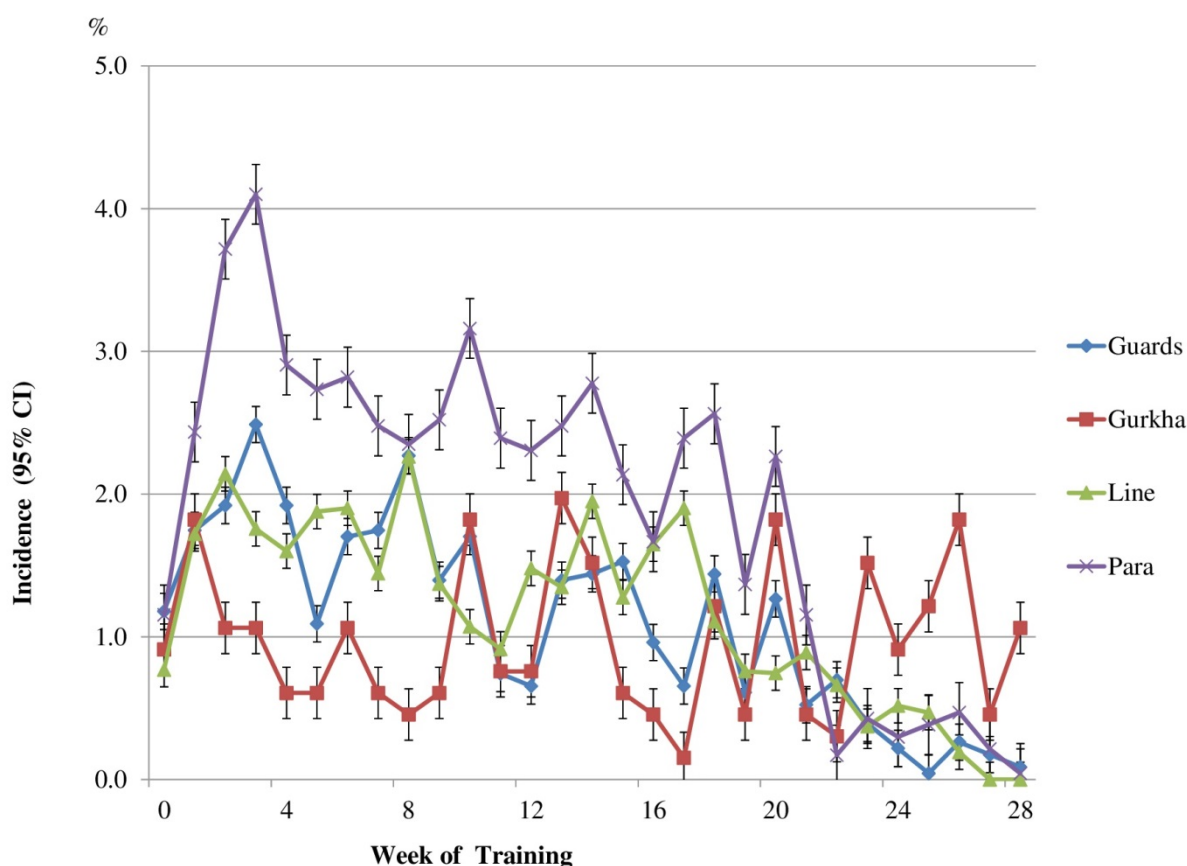


Figure 2: Incidence of injury encountered expressed in percentage with 95% Confidence Interval (CI) at each week during CIC training among four regiments.

Injury data were grouped by regiment in order to analyse inter-regimental injury patterns. No further patient demographic information was available in the database and was not available for retrospective collection due to Caldecott guidelines. Prior to commencing the CIC all recruits completed an occupational specific initial service medical assessment in order to confirm suitability to commence training. The assessment which was conducted by a Medical Officer required recruits to declare all previous illness and MSKI.

Data Analysis

Data analysis was consistent with that used in previous inter-regimental studies from the same institution [6,7]. Injury incidence proportion was calculated as: $\text{Injury incidence (\%)} = \frac{\text{number of recruits with one or more injuries}}{\text{total number of recruits in each regiment entering training each year}} \times 100$. The baseline data of the total number of recruit inflow for each regiment were retrieved from the Training, Administration and Financial Management Information System (TAFMIS) and were cross referenced and confirmed as accurate with those recruit intake figures recorded by ITC G7 Training Cell.

Descriptive analyses with a 95% confidence interval as well as relative risk were calculated to report differences between regimental MSK injury pattern and training outcome. The relative risk (RR), its standard error and 95% confidence interval (CI) are calculated according to Sharma et al. [6] and Altman [33]. Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) software v22 (IBM corporation, USA), with alpha set a priori at 0.05.

Results

Injury incidence

The five year total inflow of 12501 comprised of recruits from the Parachute Regiment (n=1910), Line Infantry (n=7799), Guards (n=1834) and the Gurkha Regiment (n=958). The annual total cumulative incidence of MSKI (with a 95% CI) for the four individual regiments was found to fluctuate (13.60% Gurkha to 80.10% para) year on year and between regiments (Figure 1).

The total five year cumulative incidence were; 66.49% (95% CI: 64.39-68.62), 38.17% (95% CI: 35.97-40.42) 33.29% (95% CI: 32.22-34.31), and 22.03% (95% CI: 19.42-24.65) for Parachute, Guards, Line, and Gurkha respectively.

Regiments	RR	95% CI	Sig	NNT (Harm)	95% CI (Harm)
GURKHA	1 (Ref)				
LINE	1.52	1.34-1.72	P<0.0001	8.82	12.17-6.17
GUARDS	1.74	1.52-1.99	P<0.0001	6.16	7.92-5.04
PARA	3.04	2.68-3.44	P<0.0001	2.24	2.43-2.08

Table 1: Musculoskeletal injury, Relative Risk (RR) and 95% confidence interval (CI) between Regiments during CIC training (2012-2017).

The relative risk of sustaining an MSKI compared to the Gurkha regiment was, 3.04 (95% CI: 2.68-3.44) times more likely for the Parachute Regiment, 1.52 (95% CI: 1.34-1.72) times more likely for Line and 1.74 (95% CI: 1.52-1.99) more likely for the Guards (Table 1).

the time and incidence of MSKI, thereby illustrating peaks in injury presentation which in turn suggest periods of greater injury risk to the recruits.

Week of training

Figure 2 presents the proportion of recruits who sustained MSKI at specific weeks of training. The gradient and peak of the line indicating

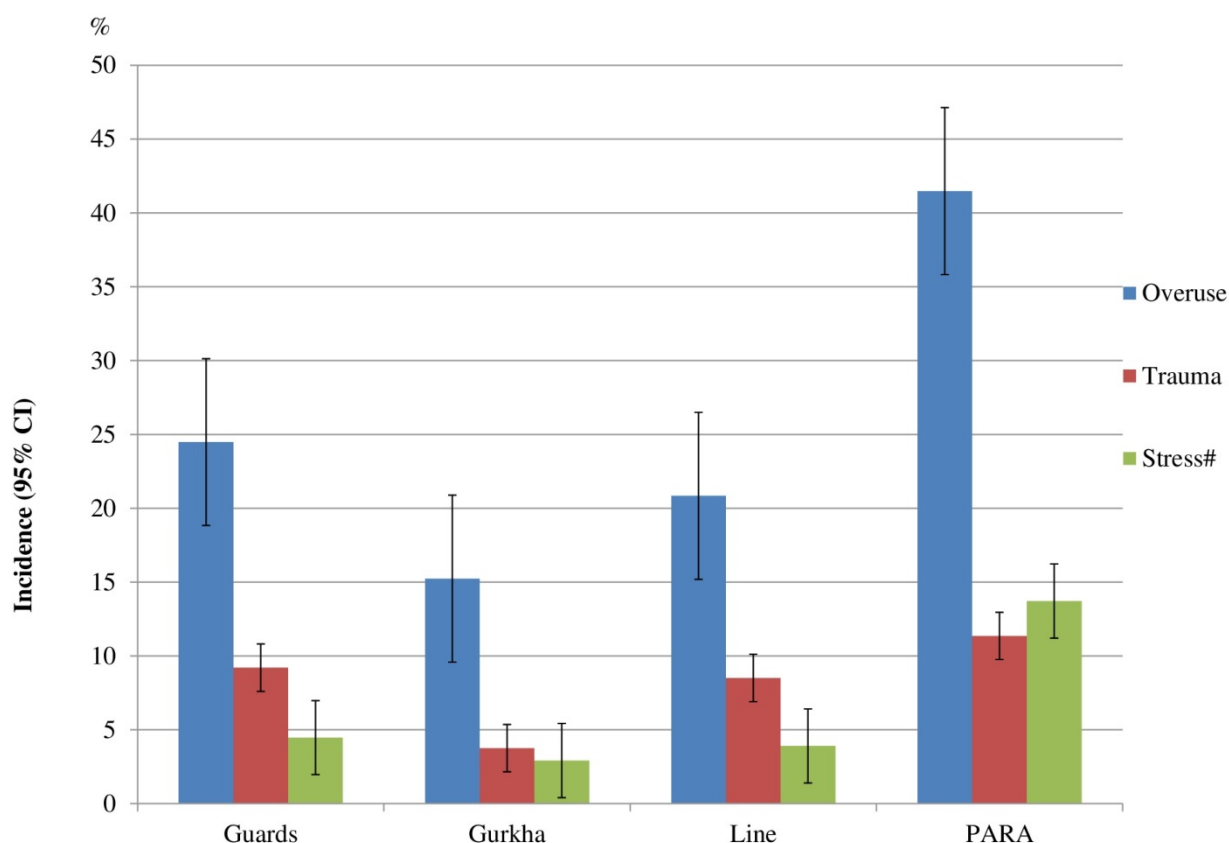


Figure 3: Incidence of injury type for each training Regiment expressed as a % with 95% Confidence Interval (CI) of the total MSKI reported from five consecutive CIC (2012-2017).

Among all MSKI 44.2% were reported within the first 8 weeks while 76% presented by week sixteen. Specifically, the point in training at which the highest incidence of injury was reported for each regiment were as a percentage for the total inflow for each week of training;

week 3 for both Parachute (4.10%) and Guards (2.49%) week 8 for the Line regiments (2.26%) and week 13 for Gurkha (1.97%) (Figure 2).

Injury type

Significant differences ($P < 0.01$) were observed between the type of injury incidence across all regiments (Figure 3). The most common type of injury for all regiments when considered as a percentage of recruit inflow was overuse (non-fracture: 15.24%-41.47%), followed by trauma (3.76%-11.36%) and then stress fractures (2.92%-13.72%) (Figure 3). Although, the pathophysiology of stress fracture is such that they are considered as a sub-classification of overuse injury they have

been separated for descriptive purposes in this paper. Due to the length of time required for treatment (85-116 days) and the far reaching associated costs to both the individual and organisation these injuries have been specifically singled for attention across the literature [1-4,21]. In addition, from a practical perspective, stress fractures, although multi-factorial in causation [1,4,16,18,34], are commonly associated with the physical overloading of inadequately prepared tissue [1,3,4,28,34].

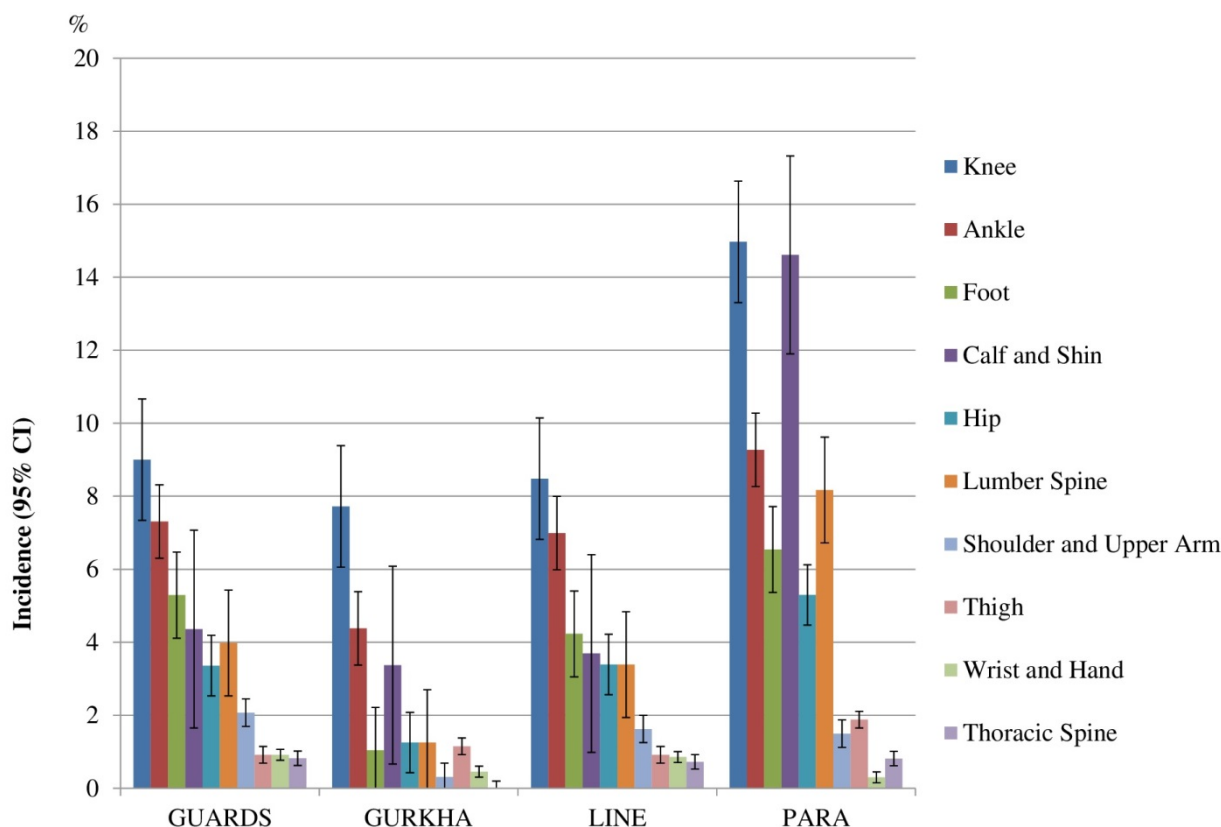


Figure 4: Total number of MSK injury in anatomical locations expressed in percentage with 95% Confidence Interval (CI) over 5 year CIC training periods for each regiments.

Consequently, stress fracture incidence is of particular interest to the military organisation as well as those trying to gain insight when designing the content of training programmes. Among all injury types, a cumulative incidence for total overuse injuries (including stress fracture) from all training regiments was observed as 77.25%.

Site of injury

Anatomical location of injury revealed knee injuries as the most frequently observed for all regiments; Gurkha (7.72%), Line (8.48%), Guards (9.0%), and Parachute Regiment (14.97%) (Figure 4).

Training outcome

Training outcome, when described as the number of recruits successfully completing both phase1 and phase 2 on the first attempt, was observed to vary year on year (Figure 4). The average first time

pass out rate differed between the regiments; 98.42% (Gurkha), 64.60% (Line), 53.10% (Guards), and 37.70% (Para).

Discussion

Injury incidence

The five year cumulative inter-regimental MSKI incidence ranged from 22.03 (Gurkha) to 66.49% (Para) and were found to be comparable with those described in previous studies [7] from the same institution. The rate of MSKI across all CIC regiments observed over both four and five years at the ITC, falls within the range reported for other military training populations (10% to 60%) as well as those published for athletic populations (25 to 65%) [35] but are considerably lower than those reported for professional dancers ; 67 to 95% [36]. However, with the exception of Gurkha (10%) the findings were lower than those observed in 2006/8 [6]. Notably, incidence rates

among the French military was higher; 75% [37]. Reduced incidence found in the Parachute Regiment compared to the 2006/8 data (86%) may be in part explained by the reduction of “junk” or unnecessary mileage in 2015. However, the observed four (66.21%) and five year (66.49%) cumulative incidence was comparable perhaps suggesting that the reduction in “junk mileage” may have contributed to reduced injury rates. However, the increased cumulative incidence observed in Gurkha recruits from 10% [6] to 24.62% over four years [2] and 22.03% over five years [3] may be in part consequence of health promotion initiatives actively encouraging the reporting of medical concerns and training injuries. MSKI reductions were observed from

the 2006/8 data for both Guards (46%) and Line (48%) compared to 38.48% and 34.22% (Line) over four years as well as the 38.17% (Guards) 33.29% (Line) found in this five year study. This may be attributed to a combination of factors, such as the introduction of new military footwear in 2013, the reduction of unnecessary (“Junk”) marching by Para Company in 2015 or most recently the modification and standardization of the training programme as part of the strategically integrated injury prevention training programme. Project OMEGA which was targeted specifically for the Line and Guards regiments in training year 2016/17 (Figure 5).

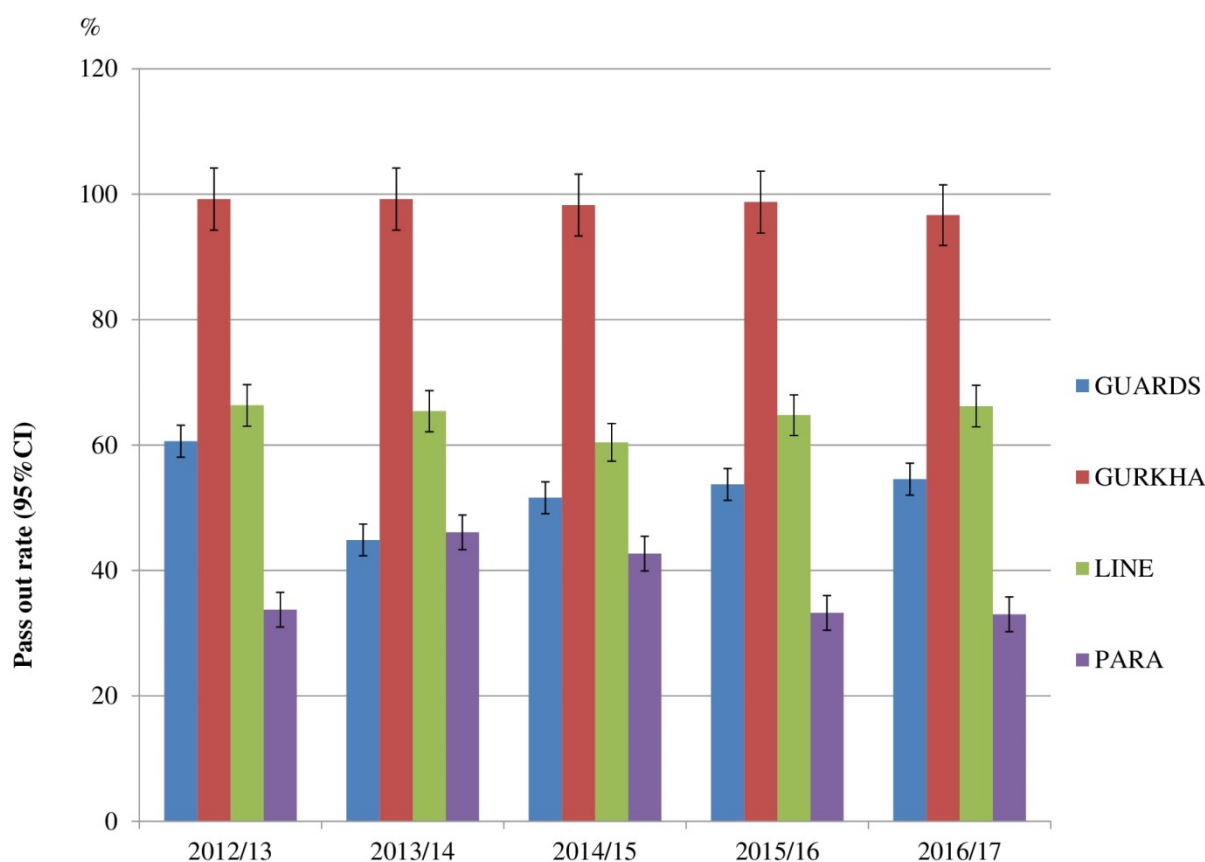


Figure 5: First attempt pass out rate with 95% Confidence Interval (CI) for each CIC infantry regiments during initial training 2012-2017.

Observed inter-regimental differences in injury incidence may in part be also explained by a combination of the individual regimental selection processes, the pre-existing physical and psychological profile of the recruit, the content and delivery of the training programme and or the willingness of recruits to report injury [1,4,11,38,39]. Indeed it is well recognised that psycho-social factors may also influence recruits decision not to seek medical advice for the management of MSKI [39]. The lower incidence of injury reported previously for CIC Gurkha [10%] might be due to a combination of factors such as; the under reporting of injury, effective self-management of injuries by recruits or the admission of a particularly robust recruit cohort over that period. Conversely, the observed five year cumulative incidence (22.3%) may represent a response to targeted health promotion initiatives, introduced in 2015/16, which actively encouraged the timely and open

reporting of MSKI throughout the CIC. In the interest of consistency, and to facilitate future comparison the method and analysis of data applied in this study repeated to that previously applied in earlier studies by both [2,3,6,7].

A Study by Sharma et al. [1] previously reported a pan regimental average injury incidence of 48.6% in all British infantry recruits over two consecutive training years (2006-2008), whilst a later study [13] from the same institution, based on 2009-2011 data, found an even higher pan-regimental average injury incidence of 58%. A reduced average of 39.06% was found between 2012-2016 whilst further reduction was observed in this five year analysis with a pan-regimental average injury incidence of 38.2% [2].

Type of injury

The five year cumulative incidence of this study, 77.25%, for total overuse injuries falls within the range found across global military organisations ranges: 61.4% [6], 80.34% [7], 65% [13], 78% [11], 82% [20,29], 90% [19]. In contrast to the findings of Davidson et al. [40] who reported acute injuries as the most prevalent, our study found overuse the most commonly reported sub-classification of all military training MSKI as well as the most commonly observed across individual training regiments. Heagerty et al. [2] investigating four years injury patterns found incidence of 76.9% (Guards) 75.2 (Line), 82.2% (Para) 80.3% (Gurkha) for overuse injuries when considered as a percentage of total MSKI. Similarly, in this study overuse injuries were found to be the most common for all CIC regiments, once again a characteristic observed globally across the literature and identified as in themselves to represent a highly preventable problem [1,11,15,13,28,41,42]. Specifically, the most common type of injury for all regiments was overuse (non-fracture), followed by traumatic and then stress fractures (Figure 3).

These sub-classifications of MSKI have considerable impact on the recruits experience through training as well as represent a threat to subsequent pass out rates and therefore apply pressure on productivity of training, operational capability and overall organisational effectiveness.

Stress fractures ranged from 2.92% (Gurkha)-13.72% (Para) in this study. This range is comparable with that reported elsewhere in the literature; 0.7-20% [1-4,34]. A recent review paper on the pathophysiology and risk factor on stress fracture [34] suggested that quantification of bone micro-architecture may aid the prediction of stress fractures incidence. However, a recent study analysing 324 recruits over a four year period found no significant differences between cases of stress fractures and the control group [43]. A review of five years injury data reported reductions in stress fracture incidence and medical discharge as compared to a previous paper [2,3]. This may in part be a result of the modification and standardisation of a training programme designed to target physical development and support of the maturing muscular-skeletal system of the young recruits. Although, the pathophysiology of stress fracture is such that they are considered as a sub-classification of overuse injury they have been separated for descriptive purposes in this paper. Due to the length of time required for treatment (85-116 days) and the far reaching associated costs to both the individual and organisation these injuries have been specifically singled out for attention across the literature [1,21,34]. In addition, from a practical perspective, stress fractures, although multi-factorial in causation, are commonly associated with the physical overloading of inadequately prepared tissue [1-4,11,13,44]. Consequently their incidence is of particular interest to the military organisation as well as those trying to gain insight when designing the content of training programmes.

Site of injury

Anatomical location of the regimental injury patterns reported in this study are similar to those previously reported [1-4] as well as those observed in other previous investigations across both military populations globally [1,10-13,44] and sporting populations [35,36].

MSKI to the lower limb are the most commonly reported across international military training establishments [1-7,11-15]. Robinson et al. [13] observed 81% of all MSK training injuries reported by British Infantry recruits to be located in the lower limb with Almeida et al.

[11] and Anderson et al. [44] reporting an even higher rate of 82%, in American military recruits.

This study found that knee injuries were found to be the most prevalent across all regiments at the ITC. The second most common site of injury was the ankle/foot for the Guards, Line and Gurkha whilst the calf and shin were most prevalent for the Parachute Regiment. These findings are in contrast to the observations of Almeida et al. [11] who reported most injuries at the ankle/foot followed by the knee, but comparable to those reported elsewhere in the literature [1,28,31]. Similar to earlier findings of Sharma et al. [1,4] injuries to the knee and specifically insertional ilio-tibial band were the most common whilst Heagerty et al. [2,3] reported the greatest incidence of training injuries at the knee in British infantry recruits.

Risk of injury

Consistent with previous findings of Heagerty et al. [2,3,7], the results from this study reveal that the risk of sustaining an MSKI was greater for recruits undergoing training in the Parachute, Guards and Line Regiments than it was for those recruits undertaking in the Gurkha training. The specific nature and content of training activity is well recognized as a key contributory factor to the development of MSKI in both military and physically active civilian populations [1-4,11-13,28,35,36]. However other factors are also recognized such as socio-cultural differences which may be considered to contribute to the observed variations in inter-regimental injury profiles [1,4,6]. The Gurkha CIC training is interspersed every 8 weeks with supplementary education courses lasting 2-3 weeks. These predominantly class room based courses therefore provide breaks from timetabled physical activity offering opportunity for relative protected physiological adaptation to exercise or "orthopaedic holidays". These breaks [45] contribute to enhance the physiological training effect and serve to reduce potential negative cumulative consequence of repeated high impact axial loading thereby reducing opportunity for tissue overload, structural failure and injury. As well as inadequate recovery time, it is widely reported that overuse muscular-skeletal training injuries often result from an abrupt increase in both volume and intensity of physical activity which are identifiable training error [1-4,11,26]. Exposing young recruits to a combination of prolonged high load physical training, mental stress, working in unfamiliar or challenging environments as well as insufficient appropriate recovery are also contributing factors to the development of potentially reducible MSK injury [1-4,28,38].

Week of training

44.2% incidence of the total injuries was observed within the first eight weeks of training for all regiments, except from Gurkha. Specifically, week three for both the Parachute (4.10%) and Guards regiments (2.49%), week eight for Line (2.26%) and week thirteen for the Gurkha (1.97%) were reported. These findings are similar to those of previous studies which identified the initial weeks of training as a key area in terms of injury prevention [1-4,11,13,26]. Previously as much as 54% of musculoskeletal injuries, across all training regiments, had been reported in the first six weeks of recruit training in British infantry recruits [13] whilst earlier work by Sharma et al. [1,4] observed high rates in the first 9 weeks of training. Similarly, Heagerty et al. [2,3,7] proposed that a lack of previous exposure to progressively robust and appropriate physical activity, low levels of baseline physical fitness as well as difficulty coping with mental stress of working within an unfamiliar environment may all potentially contribute to the high

injury incidence in the initial weeks of training. Mismatching of load with the recruits capacity tolerate exposure to new levels of physical activity in a new environment, which in itself represents psychological challenges, is likely to contribute to the high incidence of injuries in these early weeks [1,38]. However, there are potential strategies that might be adopted to manage these stresses more effectively [34], and as such may be useful when planning an injury prevention programme [1-4,27-29]. Initially it would appear that addressing a potential mismatch between training load and the bio-psycho profile of the recruit in order to enhance the individual's ability to cope with the stresses might be beneficial. It may be possible to reduce the sudden and abrupt load exerted on the recruits while the musculoskeletal system is afforded opportunity to adapt to a new intensive physical regime through the integrated delivery of neuromuscular strengthening and conditioning within which a process of positive adaptation requires careful judgement and timing [1,4]. A previous study of the CIC for the Guards regiment at ITC found that the physical demands were greatest in the first 9 weeks of training whilst the highest degree of physiological stress was observed in week two. Furthermore, the average physical activity levels at this time have previously reported to be 2.5 times greater than the basal metabolic rate, an indicator of the upper limit for maintaining energy balance [1,4,46]. Notably, 60% of the recruits who failed to pass out from training were, from this cohort, found to be exercising in excess of this threshold in the first two weeks of training. In keeping with theorem proposed by Dye [47] the exercised muscular-skeletal system may therefore be considered to be loaded out with of its "envelope of function". Repeated exposure to external physical loads which consistently breach tissue homeostasis must be considered a characteristic of negative programming, particularly in the maturing and therefore vulnerable tissues. In such cases, the sudden increase in training levels are likely to exceed muscular-skeletal tissue tolerance and thus lead to the development of structural overload, failure and subsequent injury. From a physical perspective alone, it is helpful when considering tissue tolerance to consider the muscular-skeletal system, as a complex synergistic interconnected biomechanical, neuro-physiological kinetic chain.

A mismatch in the capability of the kinetic chain to efficiently disseminate applied load presents not just the challenge of rehabilitating structural damage and potentially associated pain but also the requirement to deliver specialist targeted conditioning designed at returning the injured individual not just to pre-injured status but also addressing the neuro-muscular and potential biomechanical discrepancies such that re-injury is less likely. For many, the associated abrupt increase in physical activity, alone is widely considered a significant risk factor to the subsequent development of MSKI [1,11,28].

Training outcome

First time pass out rates fluctuated annually, from 37.70% to 98.42 % across all CIC training regiments. Comparable with a previous studies conducted by Sharma et al. [4,6], the first time pass out rate for the Parachute Regiment was significantly lower than for the other training regiments it was observed to be slightly higher than the rate previously published (35%) for this cohort [5]. The findings in this study were similar to the 38% pass out rate previously reported for recruits undergoing the CIC for the Parachute Regiment [4,6,7].

Attrition rates are, in part, a response to the recruits inability to adapt to the cumulative physical and psychologically arduous demands

of training within a military environment has been proposed in part contributory to annual attrition rates across training environments [3]. Wastage rates, however, may be reducible or even avoidable if wider considerations are made. For example, factors such as selection protocols, evidence based training programmes, evidence based injury prevention and treatment strategies are considered and implemented [1,3,16,17,26-29]. These factors, if applied correctly, have potential to reduce injury rates, improve pass out rate and reduce attrition [1,4,29].

Study strengths

The large sample size observed over a period of five years as well as the observation of data collected from cohorts consecutively trained in a relatively controlled environment, wearing similar footwear whilst subjected to an externally validated training programme are all considered strengths of this study [1-4]. Similarly, the co-located medical facility within the ITC provided injured recruits with timely access to medical care where diagnoses of the reported MSKI were made by occupationally experienced clinicians.

Study limitations

Detailed analysis of health economics was not conducted in this study. However, MSK injury management along with the associated loss of time in training and wastage due to medical discharge have previously been proposed as a useful and pragmatic proxy measure of the financial impact [1].

Economic impact of injuries on lost training days, medical support costs, along with the proposed impact on organisational deployability, operational readiness or medical discharge has not been investigated. In addition, as with previous reports from this institution the sample, although large, is all male and homogeneous in terms of recruit characteristics. Consequently, the authors stress that the observations may not be reliably applied to a female cohort undergoing infantry training. Due to the applied retrospective study design, recruits anthropometrical data were not available. It was therefore not possible to analyse and quantify the relationship between anthropometrical data, estimated training load and injury incidence. More detailed information pertaining to potential risk factors along with availability of the content of the annual training load might have enhanced data analysis and facilitated establishment of causal relationships with injury incidence across all training regiments over the five consecutive training years (2012-2017).

Conclusions

MSKI are recognised to represent a significant challenge to the organisational effectiveness of global military organisations. Consequently, there is a strong requirement to identify effective strategies for mitigation of these injuries within the training establishments. The observations made in this paper serve to provide Regimental specific analysis with associated attrition outcomes over five consecutive training years at ITC Catterick. The variance in recorded injury patterns between individual training regiments is recognised whilst the impact on wastage, training efficiency, budgets and operational effectiveness along with the introduction of an integrated injury prevention programme-Project OMEGA, further justifies the need for future in-depth reviews. As a consequence the British Army is continuing to fund further studies to mitigate against wastage and to improve the training efficiency. Further articles will be

submitted for publication addressing the issues highlighted in this paper.

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Author's Contribution

RH and JS contributed equally to this work. RH and JS conceived the study, analysed and interpreted data, drafted and critically review the manuscript and JC involved in the raw data collection and proof read the final version of the manuscript.

Conflict of Interest

The authors declare that they have no conflict of interests.

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