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Research Article

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Musculoskeletal Training Injury in Military Recruit Populations: An Integrated Prevention Strategy-Project OMEGA-(Part 1)

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Abstract

Background: Training related muscular-skeletal injury (MSKI) is a globally recognised epidemic directly affecting the deployment, retention of personnel and a threat to the effectiveness and productivity of military training organisations.

Aim: To evaluate the effectiveness of an integrated injury prevention strategy-Project OMEGA- on MSKI and training outcomes within British Infantry recruits.

Methods: An observational retrospective study design was used. MSKI and training outcome in the Project OMEGA cohort was compared with the previous 4 years published data. Total inflow for the OMEGA cohort was Line (n=1230) and Guards (n=220) whilst the total for the previous four years was Line (n=6569) and Guards (n=1614). Injury data, first time pass out and Medical discharge rates were collected and analysed.

Results: MSKI incidence for OMEGA Line (20.98%: 95% CI: 18.8-23.34) and Guards (21.82%: 95% CI: 16.87-27.74) was significantly different (p<0.001) compared to four year average for Line (34.22; 95% CI: 33.08-35.38) and Guards (38.48%; 95% CI: 36.14-40.88). Relative Risk (RR) for OMEGA Line compared to four years Line was 0.61 (95% CI: 0.55-0.69) and 0.55 (95% CI: 0.43-0.72) for OMEGA Guards compared to four years Guards.

Overuse Injury was significantly different (p<0.001) between OMEGA Line (12.52%; 95% CI: 11.12-14.34) compared to the four year average; Line (21.74%; 95% CI: 20.76-22.75) as well as between OMEGA Guards (11.36%: 95% CI: 7.81-16.23%) compared to the four year average; Guards (25.09%: 95% CI: 23.04-27.29).

Combined Medical Discharge (MD) was observed for OMEGA Line and Guards as 4.34% (95% CI: 3.41-5.51) compared to the four years Pan-ITC average of 7.72% (95% CI: 7.22-8.25). First time pass out rate for OMEGA Line (65.25%; 95% CI: 64.57-68.85) and Guards (58.17%; 95% CI: 51.58-64.50) increased compared to the previous four years average Line (64.47%; 95% CI: 63.30-65.62) and Guards (53.78%; 95% CI: 51.34-56.20).

Conclusion: Integrated injury prevention strategies-Project OMEGA-have contributed to reduced MSKI and MD within British Infantry recruits. It is recommended that OMEGA strategies could be implemented across military training establishments globally in order to reduce injury and enhance training outcome.

Key messages: MSKI are an internationally recognised bi-product of arduous military activity and undisputedly the greatest threat to the efficiency of delivering military training globally. Project OMEGA was designed to reduce the incidence of training related MSKI whilst maintaining mandated standards of physical fitness of Infantry recruits. MSK injuries significantly reduced following the introduction of a strategically designed integrated injury prevention and physical performance programme-Project OMEGA. Project OMEGA may serve to influence the design and delivery of integrated human performance and injury prevention strategies across global military training establishments. Future papers will further describe the theory and design of Project OMEGA as well as the physical performance outcomes.

Keywords: Musculo-skeletal Injury; Military recruits; Overuse injury; Stress fracture

Introduction

Musculo-skeletal injury (MSKI) has undisputedly a considerable impact on the organisational effectiveness and operational capability of military forces globally [1-4]. Incidence is reported to range widely from 20% [5], 42% [6] 47% [7], 48% [8,9], 58% [10], 59.7% [11] 75% [12] to as much as 86% in parachute regiment [2,8]. The primary cause of hospitalisations and out-patient visits, MSKI are considered accountable for up to 25 million limited working days annually [13]. The associated strain on the medical chain, loss of days in training due to temporary downgrade, placement on light duties and potential risk of subsequent medical discharge presents an on-going challenge to organisational efficiency, operational capability and represents a significant financial burden [1,9,14-19].

Indeed, the financial burden of MSKI on military budgets is globally recognised [1-4,13-16,20-22]. Estimated annual costs of $100 M have been attributed to training related injuries in the US military with specifically stress fracture management costing in excess of $16.5 M within the US Marine Corps [20]. At any one time between 15-30% of trained military personnel have been described as medically not ready to deploy (MNRD) due to muscular-skeletal injury at an estimated loss of $6 B in salary alone [21]. Swiss military insurance reported average medical costs per injury of 1,750 (CHF) or $1,925 US equating to 6.9 M CHF or $7.6 M for 25,000 army recruits per year [23]. Injury in the military has been attributed to as much as 50% of disability related medical discharges equating to $1.5 B in veteran compensation payments [22]. Furthermore, total disability payments for muscular-skeletal injury within the US military have been described as high as $21 B [20].

Recognised as the leading cause (61% or 1200 per annum) of medical discharge from both initial training and the Field Army, MSKI represent an estimated annual cost of £86 M to the British Army and a predicted £1.02 B over fifteen years [24].

However, the complex and far reaching bio-psycho-social implications of these injuries inevitably mean that the true financial cost is likely to be underestimated.

As potentially career and therefore life changing events, in the physical domain but seen more increasingly from a psychological perspective, MSKI can have far reaching impact on the individuals affected [1,2,14-16,19]. The moral responsibility to reduce these injuries is therefore strong. Unsurprisingly, training injuries have drawn international recognition with a unanimous global appetite to address injury causation, incidence and establish effective injury prevention strategies [1,2,13-16,21,22]. Notably, The NATO scientific community has embraced the challenge of identifying effective methods of mitigation whilst the British military continues to investigate a variety of strategies [15,16,25].

The British Infantry Training Centre (ITC) Catterick, a sub-division of the School of Infantry (SCHINF), is a combined Phase 1 and Phase 2 training establishment. The primary purpose of the Centre is to deliver the Combat Infantryman's Course (CIC), a minimum of twenty-six weeks, for up to 4,000 recruits per year [1,2,14-16]. Considered the most physically demanding of all initial recruit training courses in the British Army, the physical nature of training requires average daily energy expenditures in excess of 5000 Kcal [26]. However, the multi-factorial nature of military training exposes recruits to increasing levels of both physical and mental stress with training related injuries in recruits representing a higher incidence than those observed amongst trained soldiers [8,19]. Consequently, MSKI are considered as a considerable threat to delivering the CIC and therefore to the effectiveness and productivity of the ITC, which in turn impacts on the supply of trained Infanteers to the British Army [1,2,8,10,14-17].

Allocated to one of eight training companies under the command of two Infantry Training Battalions, recruits undergo a blended syllabus of generic military preparation and regimental specific soldiering skills. It consists of classroom based learning, drill, loaded marches, field exercises, weapon handling, adventurous and physical fitness training whilst distinct from the Standard Entry Line Infantry, the Guards platoons pay particular attention to foot drill and marching skills [1,2,8,14-16,18]. Ultimately, the intent of all training teams is to develop and train young civilian volunteers into Class Three Infanteer's suitably prepared to join the British Field Army [1,2].

Governance

Governance is fundamental to delivering education and training to young adults. The educational content and provision of pastoral and welfare support is assessed biennially by an external Inspectorate, the Office for Standards in Education, Children's Services and Skills (OFSTED) [1]. Likewise, medical management and delivery of the rehabilitation care pathway is also 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. The MoD's on-going commitment to service evaluation and quality improvement is an imperative and is reflected in the ITC Commanding Officers` Directive [27].

Previous studies examined the potential impact of addressing individual risk factors through isolated interventions focussing on the mitigation of specific pathology [8,9,18,19,28]. However, the complexity of multi-factorial injury causation suggested that a holistic bio-psycho-socio approach would be more beneficial when attempting to achieve wholesale organisational benefit [2,8,9,29]. Notably, it has been previously recommended [8], that the British Army should adopt a pro-active and holistic approach to identification and management of MSK training injury and that further research should be directed at identifying effective interventions for mitigation [2,8,9,29]. Once identified, it was recommended that these strategies should be integrated into the CIC utilising four stage systematic injury management framework [8,29].

The responsibility to reduce the likelihood of avoidable injuries has promoted an investigation in to what constitutes an effective prevention strategy [1,8,9,14-16]. However, the challenge of designing and delivering an effective intervention which also supports the enhancement of physical fitness as well addressing the health education of the recruits has remained elusive. Consequently, in response to the analysis of MSKI collated over four consecutive training years, an integrated injury prevention strategy- Project OMEGA was commissioned by the ITC. The purpose of this, the first in a series of papers, is to evaluate the initial effectiveness of Project OMEGA on MSKI and training outcomes.

Methods

An observational retrospective analysis was used to investigate the impact of Project OMEGA on injury patterns and training outcomes at ITC for the 2016/2017 training year. One full training year runs between 1st April and 31st March during which a total of 1450 recruits undertook the OMEGA programme. Recruits from the Parachute and

Gurkha regiments as well as non-OMEGA Line and Guards were excluded from this study.

OMEGA interventions

In keeping with the observations from previous studies a multiple interventional approach was applied to the strategic design and delivery of Project OMEGA [8,9,13,29-32]. Initial planning and design has been previously described [8,9,28-30], however, further detail of the programme will be discussed in future papers. In brief the programme included:

Leadership support: Leadership education and prevention enforcement were essential components [8,13,30,31]. Specifically, the collegiate culture of ITC, embodied by the Commanding Officers Directive [27], provided the essential firm base from which OMEGA could be delivered. It was intended that Chain of Command "buy in" would permeate down to empower the training deliverers and was therefore considered a key component of maintaining compliance.

Integrated culture: Fundamental to the OMEGA Injury prevention and Physical Performance concept was the development of an integrated culture between all stakeholders of both training delivery and healthcare provision [30]. This was essential in order to provide a synchronized and complementary programme bespoke to the training objectives of the respective regiments. The emphasis was on a collaborative responsibility for success, establishing a "shared language" grown from shared outcome goals which in turn facilitated regular and effective communication.

Planning of training: The programming of military physical training is critical to readiness but equally responsible for high injury incidence while physical activity itself has been identified as the largest and most severe health problem for the U.S Army and the one with the greatest possibility for prevention success [13,32,33]. Numerous studies have demonstrated a dose–response relationship between high impact activity and injury with incidence increasing until a critical point at which MSKI then increase disproportionately [8,29,33]. Consequently, consideration of content and delivery of physical training was fundamental to OMEGA. Previously published studies from the same institution observed 75% of all injuries [1] as overuse in nature with 45% of all injuries [1], irrespective of type, sustained within the first nine weeks [1,2,8,9]. This indicated a mismatch between the recruit's physical profile and the physiological/biomechanical capacity to effectively dissipate load through the kinetic chain [8,9,19,29]. Therefore, and in keeping with previous recommendations [8,9,19,28-30], progressive incremental loading (volume, frequency and intensity) to enhance physical conditioning and thereby reduce likelihood of injury incidence and improve physical occupational performance was strategically introduced within OMEGA. This consideration alone is particularly important to supporting the physical development and health of the maturing skeletal system in adolescent recruits. Standardisation of content and training delivery was established with increased emphasis on multi-axial, neuromuscular and proprioceptive and agility exercises [9,13,29-31] and in keeping with previous recommendations, strategies were introduced to limit the likelihood of overtraining [13,34]. Notably, recruits were advised against undertaking extra physical training in their own time whilst a 64% reduction in running mileage, compared to the first seven weeks of the previous programme, reduced high impact axial loading and provided more opportunity for targeted neuromuscular conditioning and active recovery sessions. GPS devices were issued to the training staff in order to monitor the pace (14 min miles) of loaded marches with data downloaded in order to ensure that delivery was consistent with the OMEGA design. In addition, as previously recognised in the literature, load carriage activities have been identified as a potential cause for injury [4,32]. Consequently, standardisation of load carriage (controlled progression of weight loaded activity) was implemented.

Education and health literacy: Education Leadership is fundamental to injury prevention [8,9,13,30]. OMEGA consisted of educational packages covering training content and methods of delivery for both the training staff as well as the recruits. Health education regarding sleep, exercise preparation and recovery techniques were incorporated as well as positive re-enforcement on what and when to eat and hydrate underpinned an open training culture where recruits were encouraged to ask questions and seek advice. Maintaining a watching brief, training staff actively encouraged recruits to report injuries or illness.

Injury surveillance: Surveillance of injury data was initially established within the ITC to evaluate the magnitude of MSKI incidence and training outcome whilst collection of data in this study was consistent with that applied in previously published studies from the same institution [1,2,8,9,14-16]. On sustaining an MSKI recruits presented to the co-located Medical Centre where once triaged by Combat Medical Technicians (CMT) and assessed by duty Medical Officers (MO) were referred to the Primary Care Rehabilitation Facility (PCRF) where an appointment was offered within seventy-two hours [1,14-16]. Prior to commencing the CIC all recruits underwent an occupational specific initial Army Medical examination. At this point recruits are required to declare previous illness and MSKI prior to being confirmed as suitably fit to commence training. The PCRF maintains a password protected data base in which the Administrative Assistant enters all MSKI which the designate senior physiotherapist divides in to descriptive sub-categories. Clinical Administrative Assistant and designate senior physiotherapist collected and categorised injury data prior to extracting from the departmental database. Data were independently checked by both prior to analysis. The authors were blinded to injury data collection and extraction prior to analysis in order to prevent data acquisition bias.

Outcome data: Recruit inflow for each designate platoon, first time pass out rate and Medical discharge were cross referenced from the Training, Administration and Financial Management Information System (TAFMIS) as well as with those recruit intake figures recorded by ITC G7 Training Cell prior to calculating the injury incidence and first time pass out rate. "First time pass out rate" refers to the number of recruits who have successfully completed training and passed out into the Field Army on their first attempt without having to be back termed due to injury, administration or professional reasons. This method was consistent with previously published procedures which permitted comparison with data sets published from the same institution.

Data analysis: Injury incidence proportion was calculated as: Injury incidence (%)=number of recruits with one or more injuries ÷ total number of recruits in each regiment entering training each year × 100. Descriptive analyses with a 95% confidence interval (CI), relative risk (RR), absolute risk reduction (ARR), relative risk reduction (RRR) and number needed to treat were calculated according to Sharma and Altman (2,8,34). 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.

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Results

	Total Inflow	Total injury	Incidence%	95% CI	RR	95% CI	Significance level	NNT (Benefit)	95% CI	RRR	ARR
Line 4 Years	6569	2248	34.22%	33.08-35.38	0.61	0.55 to 0.69	P<0.0001	7.55	6.22 9.60	38.72	13.24
Omega Line	1230	258	20.98%	18.8-23.34							
Guards 4 Years	1614	621	38.48%	36.14-40.88	0.55	0.43 - 0.72	P<0.0001	5.84	4.19 - 9.64	43.29	16.66
Omega Guards	220	47	21.82%	16.87-27.74							

Table 1: Incidence MSK Training Injury, Relative Risk (RR), Relative Risk Reduction (RRR), Absolute Risk Reduction (ARR) and Numbers Needed to Treat (NNT) with 95% Confidence Interval.

		Incidence % (95% CI)	RR	95% CI	z statistic	Significance level	NNT	95% CI	RRR	ARR
Overuse	Omega Line (n=154)	12.52 (11.12-14.34)	0.58	0.49 to 0.67	6.991	P<0.0001	10.85	8.58 (Benefit) to 14.75(Benefit)	42.41%	9.22%
	Line (n=1428	21.74 (20.76-22.75)								
	Omega Guards (n=25)	11.36 (7.81-6.23)	0.45	0.31 to 0.66	4.101	P<0.0001	7.28	5.09 (Benefit) to 12.83 (Benefit)	54.72%	13.73%
	Guards (n=405)	25.09 (23.04-27.29)								
Stress Fracture	Omega Line (n=19)	1.54 (0.99-2.39)	0.38	0.24 to 0.60	4.11	P<0.0001	39.69	27.30 (Benefit) to 72.64 (Benefit)	62.07%	2.52%
	Line (n=267)	4.06 (3.61-4.56)								
	Omega Guards (n=5)	2.27 (0.09-5.21)	0.50	0.20 to 1.21	1.54	P=0.1242	43.25	183.234 (Harm) to ∞ to 19.34 (Benefit)	50.43%	2.31%
	Guards (n=74)	4.58 (3.66-5.71)								
Trauma	Omega Line (n=85)	6.91 (5.62-8.47)	0.82	0.66 to 1.02	1.76	P=0.0788	66.32	621.85 (Harm) to ∞ to 31.48 (Benefit)	11.87%	1.51%
	Line (n=553)	8.42 (7.77-9.12)								
	Omega Guards (n=17)	7.73 (4.88-12.03)	0.88	0.54 to 1.42	0.53	P=0.59	93.39	34.57 (Harm) to ∞ to 19.86 (Benefit)	12.16%	1.07%
	Guards (n=142)	8.80 (7.51-10.28)								

Table 2: Injury sub-classification incidence with 95% CI.

306 MSKI were reported from a total of 1450 recruits (Line n=1230 and Guards n=230) undertaking the OMEGA programme. Each patient presenting with a new MSKI was recorded as a new episode of care with information collected according to the injury register database spread sheet.

MSKI incidence

The injury incidence for OMEGA Line was observed as 20.98% (95% CI: 18.80-23.34) and 21.82% (95% CI: 16.87-27.74) for OMEGA Guards. The average injury incidence rates for the previous four years were reported at 34.22% (95% CI: 33.08-35.38) for Line and 38.48 (95% CI: 36.14-40.88) for the Guards. These results demonstrate a relative risk of 0.61 (95% CI: 0.55-0.69) for recruits in Line and 0.55 (95% CI: 0.43-0.72) in those in the Guards Regiment compared to the respective OMEGA injury rates. The relative risk was statistically significant ($p<0.0001$) for both the Line and the Guards. RRR of 38.72 and 43.29 were observed for the Line and Guards respectively (Table 1).

Type of injury

Overuse (non-stress fracture) injuries for OMEGA were Line: 12.52% (95% CI: 11.12-14.34) and Guards: 11.36% (95% CI: 7.81-16.23) compared to the previous four years for both the Line; 21.74% (95% CI: 20.76-22.75) and the Guards; 25.09% (95% CI: 23.04-27.29) (Figure 1). RR for Line was 0.58 (95% CI: 0.49-0.67) and 0.45 (95% CI: 0.31-0.66) for Guards. This represents a significant ($p<0.001$) reduction (Table 2).

The incidence of stress fractures was observed for OMEGA Line: 1.54% (95% CI: 0.99-2.39) compared to a four years average of 4.06% (95% CI: 3.61-4.56). RR was 0.38 (95% CI: 0.24-0.60). This represents a significant ($p<0.001$) reduction. RRR was 62.07%. Stress fracture incidence for OMEGA Guards was 2.27% (95% CI: 0.09-5.21) represents a notable reduction compared to the previous four years average of 4.58% (95% CI: 3.66-5.71). RR was 0.50 (95% CI: 0.20-1.21). However this was not found to be statistically significant ($P=0.12$). RRR was 50.43%. Similarly, notable reductions were observed in the incidence of traumatic injury for both OMEGA Line and OMEGA Guards and the previous four years incidence, these reductions were not found to be statistically significant ($P>0.0788$) (Table 2 and Figure 1).

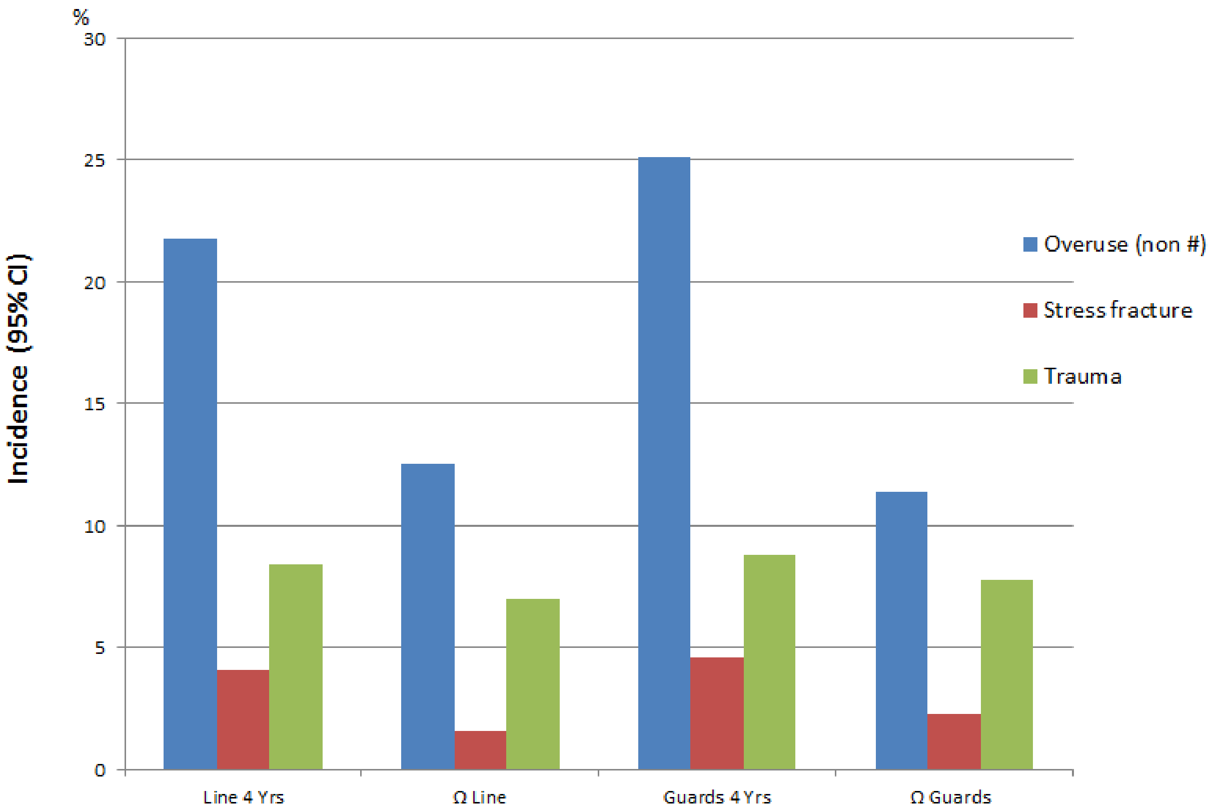

Figure 1: MSKI sub-classification as % of total Inflow for OMEGA cohort and 4 Years average.

Injury causation

Figure 2 demonstrates the hierarchy of patient reported injury causation with 95% CI. Loaded marches (boot runs Tabbing) remain the most common cause of MSKI, however the OMEGA cohort for both Line and Guards demonstrates a reduction in injury due to high impact causation; OMEGA Line (5.9%) Guards (6.82%) compared to a four year average Line (13.29%) and Guards (14.50%). Running also was found to reduce; OMEGA Line (2.03%) Guards (2.73%) compared to a previous four year average Line (5.43%) and Guards (5.64%). Marching and Drill, also considered as high impact activities, reduced for OMEGA Line (1.54%) Guards (2.27%) compared to a four year average; Line (2.16%) and Guards (3.10%).

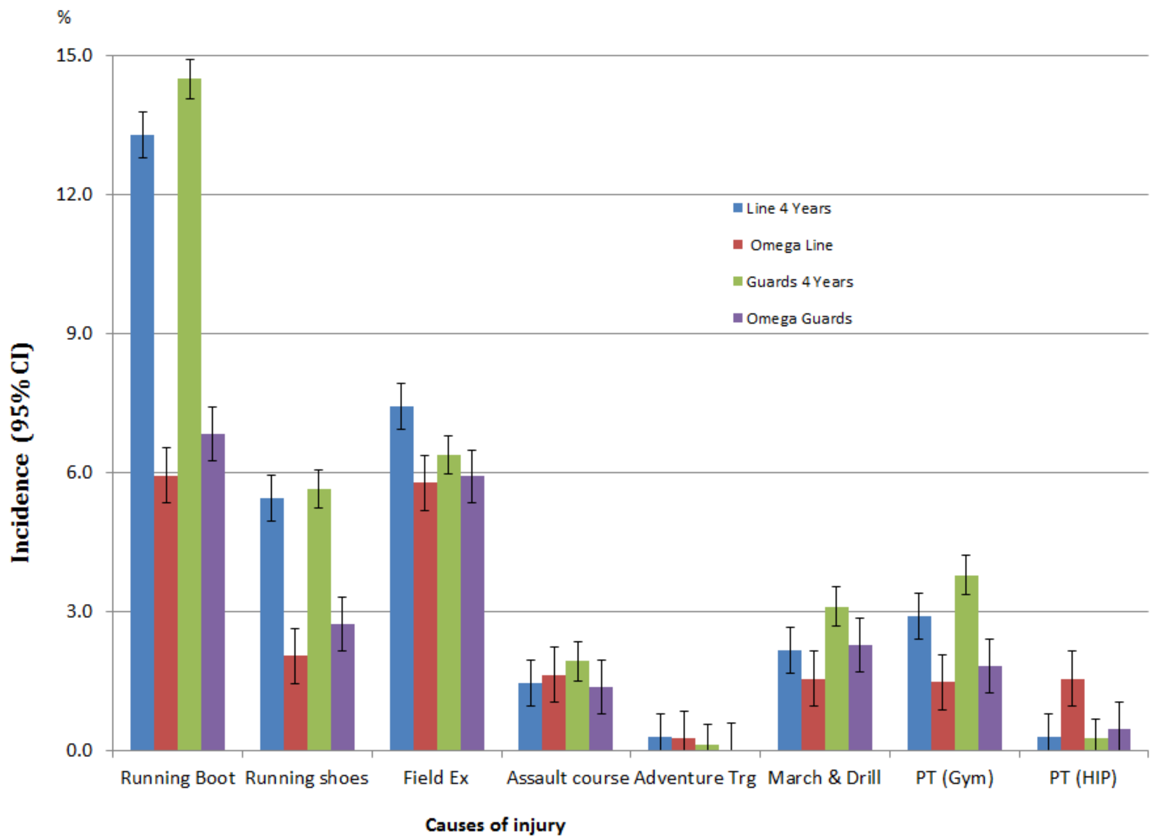

Figure 2: Patient reported MSK training Injury causation with 95% CI.

Week of training

Reduction of injury incidence with diluted distribution across the individual weeks of CIC training for OMEGA Line and Guards compared to the previous four years injury patterns. Injury distribution spikes are seen during Phase 1 (week1-12) of CIC training for both OMEGA Line (1.95 % at week 9 and 1.7% at week 12) and OMEGA Guards (2.73 % at week 7 and 1.82% at week 11) compare favourably to the previous four years average Line (2.75 % week 3, 2.73% at week 7 and 2.59% at week 9) and Guards (3.10 % week 4, 2.35% at week 9 and 2.04% at week 11).

Injury distribution spike during Phase 2 (weeks 13-26) of CIC training for both OMEGA Line (1.38 at week 18 at 0.56% at week 26) and OMEGA Guards (0.91% at weeks 15,18, 21 and 27) compares favourably to the previous four years average Line (1.6% Week 13 2.35% at week 15 2.22 at week 18 0.68% at week 22) and Guards (1.49% at week 14 1.61 at week 16 1.55% at week 19 1.42% at week 21 0.81 at week 23) (Figure 3).

Medical discharge (MD)

A reduction was observed (Table 3) in the combined OMEGA MD rate (Line: 4.30% and Guards: 4.54%) of 4.34% (n=63) (95% CI: 3.41-5.51) compared to the previous four year Pan–ITC average of 7.72% (n= 810) (95% CI: 7.22-8.25). RR was observed as 0.56 (95% CI: 0.44-0.72) and represents a statistically significant reduction ($P<0.0001$).

Training outcome

First time pass-out rate for both OMEGA Line (65.25%: 95% CI: 64.57-68.85) and Guards (58.17%: 95% CI: 51.58-64.50) were found to have increased compared to the previously four years average (Table 4).

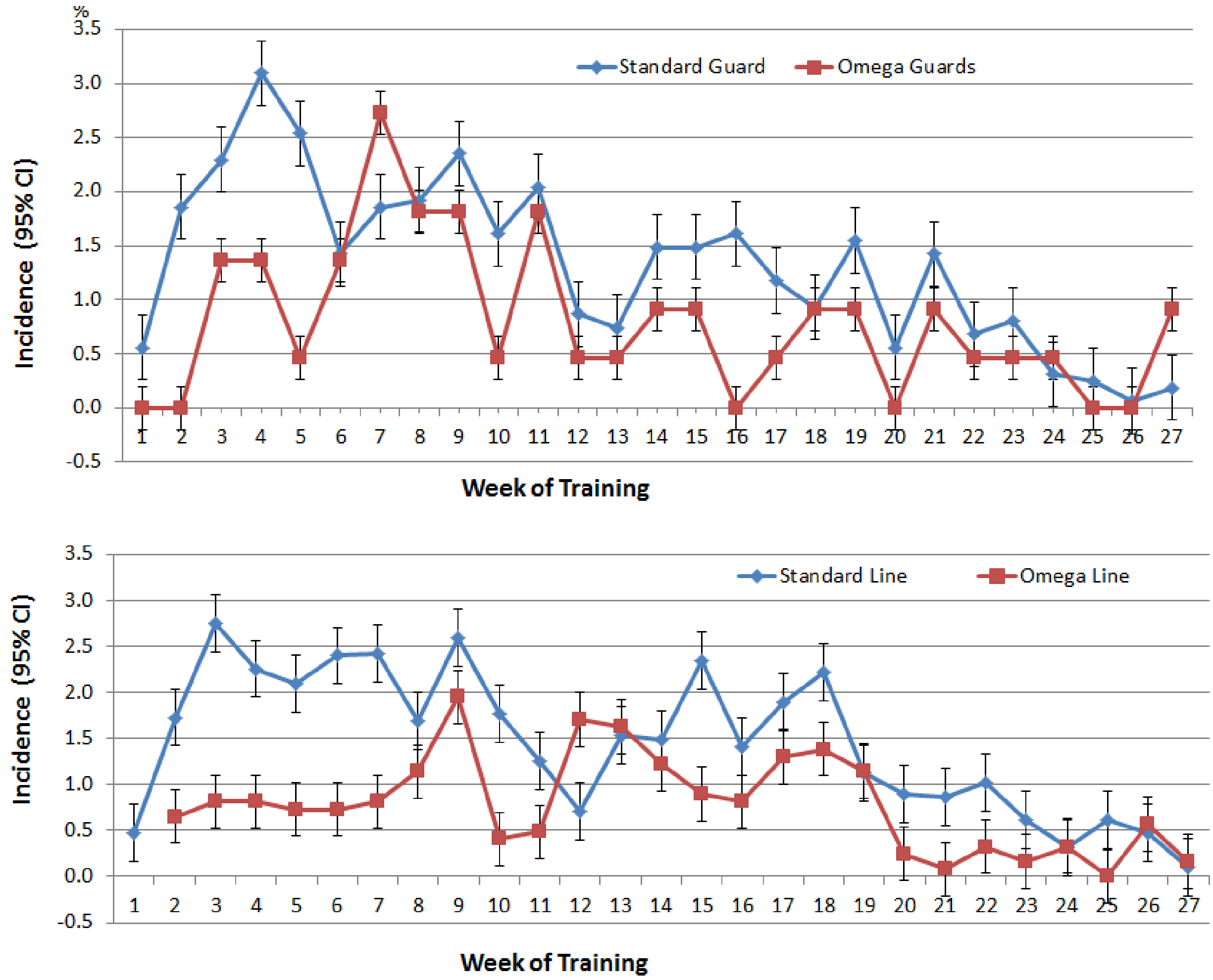

Figure 3: Week of Injury Incidence in Guards and Line Regiment (Standard & OMEGA).

	MD	95% CI	RR (95% CI)	z statistic	Significance level	NNT (95% CI)
OMEGA Line and Guards (n=1450)	4.34% (n=63)	3.41- 5.51	0.56 (0.44-0.72)	4.495	P<0.0001	29.67 (20.84 (Benefit) to 51.46 (Benefit)
Pan-ITC 4 years (n=10498)	7.72% (n=810)	7.22 -8.25				

Table 3: Medical Discharge (MD) Rate.

	Inflow number	First Time Pass-out number	FTPR	95% CI
OMEGA Line	1230	815	65.25%	64.57-68.85%
Line 4 Years	6569	4235	64.47%	63.30-65.62 %
OMEGA Guards	220	128	58.17%	51.58-64.50 %
Guards 4 Years	1614	868	53.78%	51.34-56.20 %

Table 4: First Time Pass-out rates (FTPR) for OMEGA cohort and previous four year average.

Discussion

Injury incidence

The aim of this study was to evaluate the impact of an integrated injury prevention strategy-Project OMEGA on training injury demographics during the 2016/17 training year. The injury incidence for OMEGA Line of 20.98% (95% CI: 18.80-23.34) and Guards 21.82% (95% CI: 16.87-27.74) (Table 1) represents a significant reduction (P<0.0001) compared to the previously published incidence for both Guards (46%) and Line (48%) [2,8] as well as a more recently reported four year average; Line: 34.22%; Guards: 38.48% [1]. Sharma et al. [8,9] reported a pan-regimental average incidence of 48.6% in British infantry recruits over two consecutive training years, whilst a study by Robinson et al. [10] from the same institution, based on 2009-2011 data, found an even higher pan-regimental average injury incidence of 58%. A pan-ITC rate of 39.06% was found between 2012-2016 with a reduced rate observed in a subsequent five year analysis; 38.2% [15,16]. Further regimental specific studies found rates of 34.22% and 33.29% for Line and 38.48% and 38.17% for Guards over four and five consecutive training years [14].

These results are lower than rates previously reported across international infantry training establishments. Specifically, Knapik et al. [35] reported 50.7% incidence in US Infantry and 47% over fourteen weeks US combat Engineer training, but comparable with those reported by Lisman et al. [36] who observed among male recruits undergoing a twelve week US Marine Corps Boot Camp (39.6%), and Kaufman et al. [6] who reported 33.1% in male Naval Specialist Warfare training. All of which fall beneath the 75% incidence rate for musculoskeletal lesions found among the French military [12]. Ultimately, incidence varies across different military regiments with high incidence reported amongst Infantry and Specialist Arms training considered to reflect the demanding nature and intensity [36]. The CIC is the most physically arduous and challenging initial training course in the British Army and consequently the significant reduction in incidence observed in the OMEGA cohort suggests an improved understanding in the design and delivery of integrated injury prevention strategies within military training. Notably, the incidence for the OMEGA cohort is considerably lower than the average rates of 66.21% and 24.62% observed for both the Parachute and Ghurkha Regiments between 2012 and 2016.

ARR was found to be 13.24% with RRR as 38.72% for Line. ARR was found as 16.66% and RRR as 43.29% for OMEGA Guards compared to the previous four years average for the respective regiments. The reciprocal, Number Needed to Treat (NNT) for OMEGA Line and Guards compared to respective previous four years injury was found as 7.55 (95% CI: 6.22 -9.60 Benefit) for Line and 5.84 (95% CI: 4.19 - 9.64 Benefit) for Guards (Table 1).

Injury type

In keeping with observations made across global military and athletic populations, the findings of this study indicate that overuse MSKI injuries were the most prevalent and potentially modifiable sub-classifications [1,2,8-10,14-16,34,37-40]. Significant reductions in incidence were observed for overuse MSKI (non-fracture) for both OMEGA Line (12.52% 95% CI: 11.12-14.34%) compared to the average for the previous four years (21.74%: 95% CI: 20.76-22.75) and OMEGA Guards (11.36%; 95% CI: 7.81-16.23) and the four year average (25.09%: 95% CI: 23.04-27.29). These results compare favourably to the 17% incidence in overuse MSKI observed in US Basic Army Training [39]. Recognised amongst MSKI as the cause for the greatest amount of time lost out of training and therefore representing significant impact on organisational effectiveness, stress fractures, a sub-classification of overuse MSKI, have received considerable attention across the literature. Presenting in the pelvis, spine and less frequently in the upper limb, as much as 90% of all stress fractures are lower limb with incidence rates reported to range from 0.7 to 20% across both civilian and military populations [8,9,19,41,42]. Prospective data in recruits undergoing basic training indicates stress fracture incidence of 3.3% to 8.5% in the US military, 15% among Indian Army recruits and as much as 31% in Israeli Army recruits [41,43]. Incidence of 5% reported in the Royal Marines [42] compares favourably to the 6% incidence reported in United States Marine Corps (USMC) recruits [44] and to the 5-9% reported among US SEAL Trainees [45]. The insidious onset of these prevalent injuries has been attributed to sustained repetitive strenuous activity which in turn indicates the requirement to investigate the nature of training within individual environments [6]. Incidence for the OMEGA Line cohort of 1.54% (n=19) stress fractures out of an inflow of 1230 recruits with an incidence of 2.27% (n=5) stress fractures from a total inflow of 220 OMEGA Guards. These findings are considerably less than those previously reported in the same institution [8,9,14-16,46]. Specifically, O`Leary et al. [46] reported twenty-one lower limb stress fractures out of a cohort of three hundred and twenty-four which equates to an incidence of 6.48%. It is therefore suggested that in terms of stress fracture reduction alone, the OMEGA design and implementation may have been significantly effective. OMEGA was delivered, across both Phase 1 and Phase 2 CIC training which lasted for a minimum of twenty-six weeks for both Line and Guards regiments. As far as the authors are aware, this study observed the lowest stress fracture incidence rates reported from a combined phase 1 and phase 2 Infantry training establishment. The relative reduction in total number of these injuries has direct practical organisational implications such as the identification of treatment and therefore staff training priorities as well as potential re-distribution of clinical resources. Traumatic MSKI were seen to also reduce for both OMEGA Line (6.91%; 95% CI: 5.62-8.47), Guards (7.73%; 95% CI: 4.88-12.03) compared to the average for the previous four years; Line (8.42: 95% CI: 7.77-9.12) and Guards (8.80%; 95% CI: 7.51-10.28). These findings compare favourably with incidence of traumatic MSKI across the literature, perhaps most notably against the 11% reported over eight weeks US Basic Army Training [39].

Injury cause

Although, remaining the most frequently reported individual activity attributable to MSKI, this study found high impact fast paced marching with external load (backpack up to 55 lbs) referred to as TABBING, for both OMEGA Line (5.93%) and Guards (6.82%) to have reduced compared to the previous four year average; Line (13.29%) and Guards (14.50%). The next most common, Field Exercise; OMEGA Line (5.77%) and Guards (7.43%) also demonstrated a reduction compared to the previous four years average Line (7.43%) and Guards (6.30%). This may be in part consequence of the increase in MSKI previously reported as attributable to Trauma in the 2016/17 training year [16]. Similarly, running in training shoes; was seen to reduce from a four year average; Line (5.43%), Guards (5.64%) to 2.03% for OMEGA Line and 2.73% for OMEGA Guards. Injury rates are commonly associated with prolonged bouts of vigorous weight bearing activity, specifically high mileage running [6,14-16,19,40].

Furthermore, association between frequency, duration and total amount of injuries is reported whilst disproportional increments in MSKI incidence have been found past a critical but as yet undefined point of loading [33]. However, the reduction in incidence of these high impact activities as an identifiable cause of MSKI is notable for the OMEGA cohort and it is proposed in part as a result of the OMEGA training programme which progressively introduced the recruits to high impact loading activity. Particularly encouraging was the reduction in running attributed MSKI for both OMEGA Line (2.03%) and Guards (2.73%). This reduction suggests that it is potentially possible to complete Infantry training without a high risk of sustaining a running related injury. This compares favourably with running related MSKI across the literature. This finding suggests that the progressive introduction of training variables (frequency, duration, intensity, time, type and volume) and therefore ultimately the physical conditioning and preparation of recruits to run during OMEGA was effective. Similarly, the further reduction of the already low incidence of MSKI attributable to drill and marching is suggested to again reflect the considered approach to progressive high impact loading within the OMEGA programme. Notably, loading rates and accelerations during drill manoeuvres have been reported to exceed those observed during both running and load carriage with marching generating comparable forces to running [8,29,47]. However, the findings from the OMEGA cohort suggest that these activities do not necessarily represent a high injury risk if a thorough appreciation of the physical stresses is applied to directing effective mitigation strategies.

Week of injury

OMEGA Line reported less MSKI in the first nine weeks of training (Phase 1) compared to the previous four year average. The first injury spike for the OMEGA cohort was observed at week 9 as opposed to the previously observed injury spikes at week 3, 6 and 7 (Figure 3). Previous studies reported the highest injury rates to occur within the first nine weeks of training with spikes at week 2 when physiological stress was considered greatest [8,9,48]. Similar observations were made by Almeida et al. [49] and more recently by Havenetidis et al. [50] where as much as 51.3% of training injuries were reported in the first two weeks of initial military training. It is proposed that the reduced incidence and spikes during the initial weeks of training is in part a result of the OMEGA programme which was specifically designed to progressively condition the recruits such to avoid a mismatch in physical capacity and applied load. In part, therefore the intent was to facilitate the physical development of the recruits whilst carefully progressively loading tissue within its homeostatic range or within its envelope of function [51]. In this way the aim was to better prepare the recruits for the mandated output tests and to progress through into phase 2 (week 12-26) training with a reduced likelihood of incurring injury. Similarly, OMEGA Guards presented injury spikes at weeks 3, 7 and 11 within phase 1compared with weeks 2, 4 and 9 for the previous four year average. OMEGA Line presented a reducing injury incidence through phase 2 with spikes at weeks 12, 18 and 26 in contrast to those observed at weeks 13, 15, 18, 22 and 25 for the non-OMEGA Line four year average. Heagerty et al. [1] found a four year Pan-ITC cumulative incidence of 4.7% by week four compared to that found in this study for OMEGA line (3.43%) and Guards (2.72%), 10.7% by week eight compared to 6.56% (OMEGA Line) and 9.08% (OMEGA Guards) and 24.2% by week sixteen compared to 16% (OMEGA Line) and 15.89% (OMEGA Guards). It is suggested that this again may in part be as a result of a more progressive introduction of physical activity designed to support the development of the recruit's physical conditioning throughout the course.

Medical discharge (MD)

A combined OMEGA MD rate of 4.34% or 63 recruits (95% CI: 3.41-5.51) compares favourably to a pan-ITC previous four year total of 810 recruits (7.72%) (95% CI: 7.22-8.25). The RR of 0.56 (95% CI: 0.44-0.72) was found to be significantly different (P<0.0001) with NNT 29.67 (95% CI: 20.84-51.46) (Table 3). However, the broad precision range (95% CI) suggests that MD rates fluctuated widely year on year. Irrespective of year on year variations in inflow, this represents an annual average MD of 202.5 recruits per year. The estimated training cost per recruit is £64,000 and this proportional saving in reduced MD for the OMEGA cohort therefore represents a conservative estimated annual financial saving of £8.9M in potentially preventable medical discharge costs alone (202.5-63=139.5 recruits). However, this figure does not account for all potential financial savings, such as those related to recruitment, retention, training and medical/legal costs. Nor does it reflect the financial savings made by reducing the total annual overall injury rate. Encouragingly, savings due to MD alone from OMEGA compare with previously published in year savings, notably the $5.3 m in US Army Basic Combat Training [31], the $4.5 m reported in US Marines [13] and the projected 10% annual saving ($2.5 million) in US Air Force Training [52].

Training outcome

Training outcomes and wastage rates are potentially reducible if effective integrated injury prevention strategies are correctly introduced. Although, not statistically significant, it is noteworthy that first time pass out rates (Table 4) for both OMEGA Line (65.25%) and Guards (58.17%) were found to have increased compared to the previously published four year averages from the same institution [1,14-16].

Governance inspection

The ITC received an OFSTED inspection in 2016 from which it was awarded "Outstanding Status" in the subsequent report and within which Injury Prevention initiatives were specifically highlighted for recognition.

Implications for clinicians and policy makers

This study demonstrated that meaningful reduction in training related MSKI can be made through the integrated pragmatic application of science. The results from this study may contribute far reaching benefits to organisational effectiveness and operational capability. Randomised Controlled Trials (RCT) are considered to provide higher levels of evidence, however it may not always be viable to conduct purely randomised controls across a complex multi-faceted training environment. Consequently, the findings of this study may serve to stimulate debate between clinicians and positively influence Policy Makers on alternate approaches to addressing injury reduction and performance management within military organisations.

Strengths of the study

Strengths include the large size of the OMEGA cohort (n=1450) as well as the standardized delivery of the physical development programme in a relatively controlled environment, wearing similar footwear within the same training institution. Training Centres represent a stable platform from which controlled physical activity may be designed and progressively delivered. As with the previous work of Heagerty et al. [1,14-16] these elements provide a degree of control over potentially variable extrinsic risk factors (8,9). OMEGA injury data were compared to a large sample (n=10.498) from four previous consecutive years. An open culture where recruits were actively encouraged to present injuries at the co-located medical facility where timely assessment and diagnoses was made by occupationally experienced clinicians was considered conducive to injury reporting. In addition, the method of data extraction was consistent with the methods applied in previous studies from the same institution [1,14-16].

Study Limitations

Detailed analysis of health economics was not conducted in this study. The 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. As with previous studies 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. Recruits anthropometrical data was not available and therefore it was not possible to analyse and quantify the relationship between anthropometrical data, estimated training load and injury incidence. Further analysis of the data, focussing on specific injury diagnosis, location of injury, physical output tests as well as health literacy and recruit subjective feedback is recommended in order to further describe the impact of OMEGA.

Conclusions and Recommendations

Project OMEGA has contributed to a significant reduction in the incidence of MSKI, wastage and associated financial costs due to Medical discharges for the 2016/017 training year at ITC. It is proposed that the strategies incorporated within Project OMEGA could be applied widely across physically active populations in order to reduce injury incidence and associated medical costs whilst enhancing physical performance and organisational effectiveness. Further studies could be planned to test the robustness of the OMEGA model and therefore its impact on the incidence of MSKI and physical performance in a variety of different military training centres both in the UK as well as across military populations globally. This may in turn serve to further validate the model and through doing so positively enhance organisational outputs. The findings from this paper may have broader far reaching impact, by serving to influence the design and application of training programmes and injury prevention strategies across trained military personnel globally. However, OMEGA is neither formulaic nor algorithmic in design and consequently additional papers describing the bespoke application of science behind the OMEGA strategy are therefore strongly recommended.

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Contributors

RDHH conceived, designed and directed the delivery of Project OMEGA. JS applied statistical analysis to the provided data. RDHH and JS contributed equally to the manuscript.

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Competing Interests

None

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