Lower limb injuries in New Zealand Defence Force personnel: descriptive epidemiology

Peter L. Davidson, David J. Chalmers
Injury Prevention Research Unit, University of Otago, New Zealand

Barry D. Wilson
Institut Sukan Negara, Bukit Jalil, Sri Petaling, Kuala Lumpur, Malaysia

David McBride
Department of Preventive and Social Medicine, University of Otago, New Zealand

Abstract

Objective: To describe the epidemiology of lower limb injuries in the New Zealand Defence Force (NZDF).

Method: Data from all NZDF lower limb injury claims from an 11-month period were examined for type, site, and circumstances of injury. Both injury codes and narratives were analysed, allowing each injury event to be classified according to mechanism of injury, object involvement, and activity at the time of injury, as well as type and site.

Results: The commonest lower limb musculoskeletal injuries were ankle sprains or strains (35%) and knee sprains or strains (16%). Most commonly, injuries were due to acute over-exertion (37%), involved no other person (50%), and occurred while running (28%) or playing team sports (25%). The injury rate for recruits was more than five times that of trained personnel.

Conclusions: Potential interventions should target ankle sprains primarily, but also knee sprains and fractures. Fractures, while accounting for only 6% of lower limb injuries, should be a priority because of their high medical and time-lost costs. Interventions must also take into account the high incidence of injuries involving individuals alone and sustained during recruit training. The study also demonstrated that analysis of military injury narratives provides valuable extra information on injury causation and the circumstances of injury, and allows more accurate characterisation of the injury process.

Implications: This study will provide the basis for development of an injury prevention strategy for lower limb training injuries in the NZDF.

Key words: Injuries; epidemiology; lower limb injuries; military personnel statistics and numerical data; data collection methods.

(*Aust N Z J Public Health.* 2008; 32:167-73)
doi:10.1111/j.1753-6405.2008.00195.x

A high incidence of injuries in physical training in the military has been reported for several countries, with musculoskeletal injuries of the lower limb predominating.[1-5] Reported incidence rates for musculoskeletal injuries range from 3.3 to 34.4 injuries per 100 person-months, depending on the level of the service involved (i.e. infantry, recruits or commandos).[5] In an Australian Defence Force (ADF) study, sport and physical training accounted for more than 50% of injuries.[3]

Lower limb training injuries are of concern to the New Zealand Defence Force (NZDF). In 2002 and 2003, lower limb injuries to regular members of the NZDF made up almost half of all NZDF injuries that resulted in a compensation claim being lodged with the Accident Compensation Corporation (ACC). (The ACC is the administrator of New Zealand's national, comprehensive, no-fault injury compensation scheme.) The treatment of lower limb injuries can be difficult, expensive and time-consuming,[6] and lower limb injury has been associated with an increased risk of attrition in military service.[7]

Little research on the epidemiology and aetiology of injuries in the NZDF has been reported in the scientific literature. Due to the relatively small and specialised nature of the NZDF, the types of injuries experienced by this force may not be the same as for defence forces in other countries. The aim of this study was to describe the epidemiology of lower limb injuries in the NZDF as an important first step towards understanding the aetiology of these injuries and developing preventive strategies. The approach used and the findings may also have relevance to other military forces.

Methods

The data used in this study were extracted from ACC claim forms lodged when injured NZDF army, navy, airforce and headquarters personnel visited a medical officer for treatment. Within the NZDF, injury claim forms are lodged for all injuries that require further treatment or investigation, or restrict the person's ability to participate fully in training or operations. The NZDF is an ACC Accredited Employer, which means that it manages the work-related injury claims made by its personnel on behalf of ACC. The claim forms are partially completed by claimants, who are required to describe in narrative form the circumstances surrounding their injury. The remainder of the form is completed by the treating medical officer, who provides a diagnosis, a referral for any further treatment that may

Submitted: May 2007 **Revision requested:** September 2007 **Accepted:** February 2008

Correspondence to:
Dr Peter Davidson, Injury Prevention Research Unit, Dunedin School of Medicine, University of Otago, PO Box 913, Dunedin 9054, New Zealand. Fax: +64 3 479 8337; e-mail: peter.davidson@ipru.otago.ac.nz

Table 1: Lower limb injuries by type and site.

Type	Site						Total	
	Upper leg[a]	Knee	Lower leg	Ankle	Foot	Toes	n	%
Sprain or strain	171	176	113	388	40	1	889	79.7
Contusion	17	36	11	5	2	3	74	6.6
Fracture	0	1	24	11	15	11	62	5.6
Superficial (laceration)	1	9	14	0	9	0	33	3.0
OOS/RSI	0	4	1	10	0	0	15	1.3
Dislocation	1	4	0	0	1	3	9	0.8
Hernia	5	0	0	0	0	0	5	0.4
Gradual process: local inflammation	0	1	2	0	0	0	3	0.3
Other: specified[b]	2	0	3	0	0	0	5	0.4
Other: unspecified	0	3	4	0	0	0	7	0.6
Unknown	1	8	5	0	0	0	14	1.3
Total n	**198**	**242**	**177**	**414**	**67**	**18**	**1,116**	**100.0**
Total %	**17.7**	**21.7**	**15.9**	**37.1**	**6.0**	**1.6**	**100.0**	

Notes:
(a) Hip and thigh.
(b) Includes burns, pain syndromes, toxic/adverse effect.

be required, and an indication of any incapacity arising from the injury that will prevent return to work.

A database of all NZDF lower limb injury claims lodged during the 11-month period from 1 July 2002 to 31 May 2003 was provided by the NZDF. Under NZDF's contract with the ACC, the NZDF is able to use claim-related information for research purposes as long as particular claimants cannot be identified. The database included information on gender, age, type of injury and injury site, and a narrative by each claimant describing the injury event (e.g. "physical training – hurt Achilles tendon while running during fitness test"), but individual claimants were not identifiable. Injury site and type were categorised according to the Read classification system operated by the NZDF.[8] Lower limb injuries were defined as injuries to the hip, thigh, knee, lower leg, ankle, foot and toe.

For the purposes of this study, the narrative on each NZDF claim record was searched to identify and code: 1) the mechanism of injury; 2) the object that produced the injury (i.e. the object that conveyed the energy responsible for the injury); and 3) the activity at time of injury. The codes and definitions employed were as specified in the International Classification of External Causes of Injuries (ICECI) coding frame,[9] with the addition of a small number of military-specific codes such as 'physical training' under the activity category. The narratives were searched automatically by a customised computer program developed using MATLAB® (MathWorks, Natick, MA, USA, 2003) and Excel (Microsoft® Corporation, USA, 2003), for key words associated with each ICECI code, and classified accordingly. Each narrative was then manually reviewed and recoded where necessary. Within mechanism of injury, over-exertion injuries were coded as 'acute'

Table 2: Lower limb injuries by mechanism, type and site for all claimants (n=1,116).

Mechanism	Sprain or strain: n (%)[a]				Fracture	Other	Total
	Upper leg	Knee	Lower leg	Ankle	n (%)[a]	n (%)[a]	n (%)[b]
Over-exertion							**659 (59)**
Acute over-exertion	49 (12)	79 (19)	62 (15)	186 (45)	9 (2)	25 (6)	410 (37)
Unspecified physical over-exertion	25 (16)	42 (27)	27 (18)	33 (22)	10 (7)	16 (10)	153 (14)
Cumulative loading	20 (21)	14 (15)	13 (14)	9 (9)	9 (9)	31 (32)	96 (8)
Blunt force							**435 (39)**
Impact with person	26 (22)	12 (10)	3 (3)	43 (36)	12 (10)	23 (19)	119 (11)
Fall	19 (16)	7 (6)	1 (1)	43 (37)	5 (4)	20 (17)	117 (10)
Trip or slip	20 (21)	9 (9)	4 (4)	51 (54)	9 (9)	24 (25)	95 (9)
Other[c]	17 (16)	8 (8)	3 (3)	23 (22)	7 (7)	46 (44)	104 (9)
Other[d]	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	21 (95)	22 (2)

Notes:
(a) Percentage of claims in minor mechanism category.
(b) Percentage of all claims.
(c) Includes jumping on the same level, and striking static or moving objects.
(d) Includes cut by sharp object and unspecified mechanisms.

if a specific traumatic event was recalled as being responsible for the injury (e.g. “foot rolled on rock”, “pulled muscle suddenly”), ‘cumulative’ if the pain had gradually increased over time or occurred after the activity ceased (e.g. “pain after run”), or ‘unspecified’ when an injury could not be attributed to acute or cumulative causes (e.g. “injured during running”). Drawing a distinction between acute and cumulative over-exertion injuries can be useful because the type of over-exertion involved may reflect the pattern of training leading to injury.[1]

All statistical analyses were undertaken using SAS 8.0 (© 1999 SAS Institute Inc., Cary, NC, USA). The 95% confidence intervals for incidence rates were estimated assuming a Poisson distribution.

Results

A total of 2,575 claims for all sites of injury (i.e. not only the lower limb) were made during the study period. With approximately 10,500 members of the NZDF active during this period, the claim rate was 267 claims per 1,000 person-years (95% confidence interval 257-277). Of the 2,575 claims, 1,116 were for musculoskeletal injuries to the lower limbs (43% of all claims or an incidence rate of 116 claims per 1,000 person-years (95% CI 109-122)). The age of claimants ranged from 17 to 55 years, with a mean of 26 years. Table 1 summarises the distribution of lower limb injuries by type and site. The leading injuries (by type and site) were sprains or strains (hereafter referred to as ‘sprains’) to the ankle (35%), knee (16%), upper leg (15%) and lower leg (10%). It was not possible to separate the ‘upper leg’ injuries into hip and thigh injuries from the diagnosis codes used. Tables 2 to 4 provide detail on the circumstances of injury by mechanism, object and activity, broken down by injury type and site.

The most common mechanism of lower limb injury was over-exertion, followed by blunt force (see Table 2). Under each of these major categories are ranked the more common minor categories. Over-exertion injuries were predominately due to acute events, and the commonest mechanism of blunt force injury was impact with another person and falling. Ankle sprains were the most common injury arising from all but one of the specific injury mechanisms. The exception was cumulative loading, for which the most common injury was upper leg sprain. Fractures constituted approximately 10% of the lower limb injuries involving cumulative loading, impact with a person, and tripping or slipping.

Table 3 summarises the distribution of injury by the objects that conveyed the damaging energy to the injury site. The most common object involved was person (self or other), followed by ground surface. Most of the injuries involving person involved only the self, and resulted from internal force (e.g. muscle force or body weight). With the exception of sports equipment injuries, ankle sprain was the most common injury for all of the specified minor object categories. Among sports equipment injuries, sprains of the upper leg and knee occurred as frequently as ankle sprains.

The most common activities at the time of injury were individual athletic activities/sports, team activities/sports, and physical training (see Table 4). The most common individual activity associated with injury was cross-country jogging/running. Team activities associated with injury included rugby, soccer and basketball, with the highest number of injuries being sustained while playing rugby. Almost half of the claim records for physical

Table 3: Lower limb injuries by object, type and site for all claimants (n=1,116).

Object	Sprain or strain: n (%)[a]				Fracture	Other	Total
	Upper leg	Knee	Lower leg	Ankle	n (%)[a]	n (%)[a]	n (%)[b]
Person							**731 (66)**
Self: internal force	60 (12)	108 (22)	89 (18)	145 (30)	22 (5)	60 (12)	484 (43)
Another person: unspecified	14 (18)	8 (10)	2 (3)	28 (35)	9 (11)	19 (24)	80 (7)
Self: impact with ground	22 (30)	9 (12)	3 (4)	25 (34)	6 (8)	9 (12)	74 (7)
Another person: tackle	12 (30)	4 (10)	1 (3)	14 (35)	3 (8)	6 (15)	40 (4)
Other[c]	15 (28)	12 (23)	4 (8)	12 (23)	1 (2)	9 (17)	53 (5)
Ground surface							**217 (19)**
Hole/ditch/gutter	11 (17)	2 (3)	2 (3)	42 (66)	3 (5)	4 (6)	64 (6)
Surface material	5 (11)	1 (2)	1 (2)	21 (47)	1 (2)	16 (36)	45 (4)
Uneven surface	3 (7)	4 (9)	5 (11)	28 (62)	1 (2)	4 (9)	45 (4)
Sloping surface: hill	11 (25)	7 (16)	1 (2)	20 (45)	2 (5)	3 (7)	44 (4)
Other[d]	2 (11)	3 (16)	1 (5)	6 (32)	0 (0)	7 (37)	19 (2)
Other							**168 (15)**
Building component	3 (8)	2 (6)	0 (0)	15 (42)	3 (8)	13 (36)	36 (3)
Sport equipment	8 (24)	6 (18)	1 (3)	7 (21)	4 (12)	8 (24)	34 (3)
Vehicle	5 (15)	2 (6)	2 (6)	10 (30)	4 (12)	10 (30)	33 (3)
Other[e]	5 (8)	3 (5)	1 (2)	15 (23)	3 (5)	38 (58)	65 (6)

Notes
(a) Percentage of claims in minor object category.
(b) Percentage of all claims.
(c) Includes object is unspecified as another person or self.
(d) Includes wet surfaces, cliffs and waterways.
(e) Includes tools, boots and furniture.

training injuries (96/218) did not specify the actual physical training activity involved. Of the specified physical training activities, drill/marching was most commonly associated with injury. Ankle sprain was the most common injury for all of the minor single activity categories except track and field, where knee and lower leg sprains were the most common.

Table 5 presents a summary of the claims and distributions by mechanism, object and activity for each service within the NZDF and for training status. The army lower limb injury rate was the highest of the four services and one-third higher than that for the NZDF overall. Some differences in injury distribution between the services were identified. The airforce, for example, differed from the army in three respects: the proportion of injuries involving ground surface was one-third that of the army; the proportion occurring in team activities/sports was nearly double that of the army and the proportion occurring in physical training was nearly one-third that of the army. The incidence rate for recruits (new personnel undertaking basic training) was more than five times that for trained personnel (personnel who had completed basic training in the past and were part of the regular force).

Discussion

This is the first comprehensive descriptive study of the epidemiology of lower limb injuries in the NZDF to be published. It confirms that musculoskeletal injuries to the lower limbs are common in the NZDF, and reveals that this force's injury experiences are generally similar to those reported for other defence forces.

The most common NZDF lower limb injuries were sprains of the ankle, followed by sprains of the knee. These findings are consistent with reports on military personnel in other countries.[1-3] Although sprains and contusions were more common, fractures made a notable contribution in this study. Medical and lost-working-time costs associated with these injuries can be considerably higher than for the more common sprains and contusions.[3,10] An ADF study found that fractures resulted, on average, in nearly twice as many working days lost per injury case than sprains did and, although contributing only one-third as many cases as sprains, fractures contributed approximately the same number of hospital bed days.[3] There is evidence that the incidence of some of these types of injuries can be reduced by intervention strategies such as ankle bracing,[6,11] balance board training[6,11,12] and the use of shock-absorbing insoles.[6,13] Characterisation of the prevalence and circumstances of particular injuries is a valuable first step in identifying the most appropriate strategies to employ.

Mechanism

The most common mechanism of injury was over-exertion, followed by blunt force. This is consistent with research reported

Table 4: Lower limb injuries by activity, type and site for all claimants (n=1,116).

Activity	Sprain or strain: n (%)[a]				Fracture	Other	Total
	Upper leg	Knee	Lower leg	Ankle	n (%)[a]	n (%)[a]	n (%)[b]
Individual activities/sports							**432 (39)**
Jogging/running: cross country	40 (13)	41 (13)	64 (21)	111 (36)	11 (4)	40 (13)	307 (28)
Walking	7 (13)	4 (8)	1 (2)	27 (52)	3 (6)	10 (19)	52 (5)
Track and field	2 (6)	10 (32)	9 (29)	4 (13)	0 (0)	6 (19)	31 (3)
Other sports[c]	14 (33)	8 (19)	4 (10)	9 (21)	6 (14)	1 (2)	42 (4)
Team activities/sports							**284 (25)**
Rugby	23 (17)	32 (24)	7 (5)	49 (37)	3 (2)	20 (15)	134 (12)
Soccer	12 (19)	10 (16)	3 (5)	20 (31)	7 (11)	12 (19)	64 (6)
Basketball	3 (13)	0 (0)	0 (0)	18 (75)	1 (4)	2 (8)	24 (2)
Other[d]	9 (15)	11 (18)	2 (3)	27 (44)	2 (3)	11 (18)	62 (6)
Physical training							**218 (20)**
Unspecified	14 (15)	22 (23)	10 (10)	24 (25)	10 (10)	16 (17)	96 (9)
Drill/march	12 (18)	11 (17)	3 (5)	25 (38)	4 (6)	11 (17)	66 (6)
Other specified[e]	15 (27)	8 (14)	2 (4)	17 (30)	2 (4)	12 (21)	56 (5)
General activities							**133 (12)**
Climbing out of equipment	7 (24)	2 (7)	1 (3)	11 (38)	1 (3)	7 (24)	29 (3)
Working with equipment	1 (4)	1 (4)	0 (0)	3 (13)	3 (13)	16 (67)	24 (2)
Other[f]	10 (13)	8 (10)	2 (3)	27 (34)	6 (8)	27 (34)	80 (7)
Other activities							**49 (4)**
Unspecified activity	4 (15)	1 (4)	1 (4)	7 (26)	1 (4)	13 (48)	27 (2)
Unspecified sport	3 (14)	2 (9)	4 (18)	9 (41)	2 (9)	2 (9)	22 (2)

Notes:
(a) Percentage of claims in minor activity category.
(b) Percentage of all claims.
(c) Includes squash, gymnastics and parachuting.
(d) Includes netball, volleyball and unspecified.
(e) Includes course, assault and circuit.
(f) Includes standing, sitting, stair-climbing, jumping and lifting.

by the ADF, which identified 'body stressing' (a synonym for over-exertion) as the mechanism associated with the most casualties and work days lost.[3] It is useful to further distinguish over-exertion injuries into acute and cumulative. Previous research on military training injuries has used injury diagnoses as the sole means of classification of acute and cumulative injuries (sometimes referred to as trauma and overuse injuries),[1,14,15] with Piantanida et al. (2000), for example, classifying all non-stress fractures, sprains/strains and dislocations as acute injuries.[15] The use of injury narratives has been identified as providing more information than coded data on precipitating mechanisms of injury.[16,17] In this study, analysis of the NZDF claims record narratives enabled us to more accurately distinguish between acute and cumulative causes of over-exertion injury than would have been possible from injury diagnosis codes alone, and revealed acute over-exertion to be the most common type in the NZDF. Such narrative analysis also enables postulation of the forces causing the injury. For example, we were able to show that ankle sprains dominated the acute over-exertion injuries but not the cumulative or unspecified acute/cumulative injuries. An explanation for this could be that large, sudden forces at the ground surface are more likely to injure the flexible ankle joint, while smaller repetitive forces that are transmitted throughout the lower limb may express their effect at any lower limb site.

Object

Two-thirds of injury events involved only persons, with the majority of these involving only the injured person, i.e. a non-contact injury. Musculoskeletal injuries occur because forces experienced by the muscles, connective tissues and/or bone exceed their mechanical capacity, both in terms of load and loading rate. Injurious forces can be generated by the person alone, with no external contact with an object, through a combination of excessive muscle force, deceleration and body weight (for example, a joint sprain due to a sudden stop or change of direction). The 'object' in such cases was classified as 'self: internal force', even though body weight is technically an external force. This ambiguity arises because mass is an internal property but force of gravity is generated by an interaction between the person and an external object, namely the earth. These types of 'non-contact' injures are common in sports such as Australian football.[18] With 'self: internal force' the predominant cause of injury in the NZDF, priority should be given to addressing this when considering potential prevention measures.

The next most common object identified was 'ground surface', with the ankle the most common injury site. The ankle/foot complex forms the body's vital connection with the ground surface and accommodates both surface shock and uneven terrain.[19,20] The most common mechanism of injury in ankle sprains is forced plantar-flexion and inversion as the body's centre of mass moves over the joint.[21] Uneven surface terrain is, therefore, likely to increase the probability of ankle sprain occurrence. Previous research has found that persons with a higher moment of inertia (i.e. taller and heavier) are more vulnerable to surface anomalies and at greater risk of ankle sprain during military training.[22]

Activity

The most common activity being undertaken at the time of injury was 'individual activities/sports' such as running and walking, which is consistent with previous studies.[1] Team sports also

Table 5: Lower limb injuries by service and training status (n (%))

	Service				Trained	Recruits
	Army	Navy	Air Force	Headquarters		
Total claims	739 (66)	145 (13)	157 (14)	75 (7)	943 (84)	173 (16)
Estimated population	5,000 (48)	2,300 (22)	2,100 (20)	1,100 (10)	9,600 (91)	900 (9)
Claim rate per 1,000 person years (95% CI)	160 (149-171)	69 (58-80)	81 (70-94)	75 (59-93)	107 (101-114)	630[a] (543-726)
Mechanism						
Over-exertion	443 (60)	78 (54)	93 (59)	45 (60)	556 (59)	106 (61)
Blunt force	288 (39)	62 (43)	60 (38)	26 (35)	368 (39)	64 (37)
Other	7 (1)	4 (3)	5 (3)	4 (5)	19 (2)	3 (2)
Object						
Person	473 (64)	90 (62)	119 (76)	47 (63)	632 (67)	99 (57)
Ground surface	163 (22)	29 (20)	13 (8)	14 (19)	160 (17)	55 (32)
Other	103 (14)	26 (18)	25 (16)	14 (19)	151 (16)	17 (10)
Activity						
Individual activities/sports	296 (40)	51 (35)	53 (34)	31 (41)	358 (38)	74 (43)
Team activities/sports	170 (23)	38 (26)	63 (40)	11 (15)	255 (27)	29 (17)
Physical training	163 (22)	23 (16)	13 (8)	17 (23)	170 (18)	43 (25)
General activities	74 (10)	28 (19)	17 (11)	12 (16)	113 (12)	16 (9)
Other activities	30 (4)	4 (3)	9 (6)	4 (5)	38 (4)	9 (5)

Notes:
(a) The recruit claim rate of 210 (181-242) was scaled up because basic training takes only four months.

contributed significantly to NZDF injuries, as found in studies on other military forces,[3,14] with rugby, soccer and basketball being the major contributors. Nearly two-thirds of lower limb injuries were sustained while participating in sporting activities. A report for the ADF showed that sport was responsible for 40-45% of military injuries and that the highest injury rates were associated with rugby and soccer.[3] The NZDF injury incidence may have a higher sport contribution than the ADF because of differences in the definition of sport used by the two forces. Of specified physical training activities, marching and drills contributed the highest proportion of injuries, as found in a South African study.[23]

Service

The injury rate for army personnel was at least twice that of navy, airforce and headquarters personnel. This is comparable to the United States (US), where the navy has been reported as having 53%, and the airforce 49%, of the army's rate of hospitalisations due to all types of injury.[24] The higher rates for army personnel are likely to be due to a greater exposure to risk (i.e. more time spent training in the field).[24] This study showed that the proportion of general activity-related injuries in the navy was almost twice that in the army. This is likely to be the result of navy personnel spending more time in confined spaces and less time in marching and drill activities than their army counterparts. The study also showed that the airforce had a lower proportion of ground interaction injuries and injuries due to physical training than the army, and a greater proportion of team sport injuries. These results are likely to reflect the lower level of exposure of airforce personnel to field work and the even terrain of air bases. With three air bases in the NZDF, however, inter-base full contact rugby competitions and training for these events occur frequently.

The injury rate for recruits was more than five times that for trained personnel, indicating that the recruit training period should be a priority for injury prevention interventions. The recruit injury incidence is probably due to their intense and concentrated initial training regime, lack of training experience, and a lower level of physical fitness on entry to the training program. Previous research has found that military personnel with low levels of physical fitness have a significantly higher incidence of training injuries.[10,25-27] Analysis of the injury narratives revealed that recruits had nearly twice the frequency of ground impact injuries, a greater frequency of training-related injuries and a lower frequency of team sport injuries than trained personnel. These results reflect the nature of the NZDF recruit training program that involves intensive field work but limited time in team sports.

Limitations

There were some limitations to this study. First, it was limited to the data available from the ACC claim forms. Data on personal risk factors were not available, but risk factors such as physical fitness, BMI, and cigarette smoking history have been studied extensively in other military populations.[2,5,26-28] Second, the injury claim data did not include wilfully self-inflicted injuries (such injuries being excluded from ACC entitlements at the time) or injuries that were not work-related (as only work-related injuries are managed by NZDF under the Accredited Employer Program). Finally, the narrative analysis was dependent on the ability of the injured person to accurately recall details of the injury event. A more structured narrative would be useful for future investigations of the circumstances of injury. The claim form could be structured to directly inquire about injury mechanism, object and activity, but the design of the form and accompanying instructions would have to be carefully developed so as not to introduce systematic bias.

Conclusions

This study has confirmed that musculoskeletal injuries to the lower limbs are common in the NZDF. It has also demonstrated that injury narrative analysis is a useful tool for the investigation of military injuries, providing valuable information on the causation and circumstances of injury. Various injury prevention interventions have been reported to reduce the incidence of lower limb injuries. The narrative information, by allowing a more accurate characterisation of the injury process, provides a basis for selection of appropriate injury prevention strategies. Our findings indicate that strategies should be sought which target ankle sprains, knee sprains and fractures, in this order of priority, and take into account the high incidence of non-contact injuries. Recruits were identified as having a high lower limb injury incidence rate, and so particular emphasis should be put on injury prevention in this group.

Acknowledgements

We wish to thank Suzanne Wilson, Shaun Stephenson and Gabrielle Davie of the Injury Prevention Research Unit, University of Otago, and Lisa McKubre of the Accredited Employer Program Unit, Personnel Branch, Head Quarters NZDF, for their assistance in this study. This study was funded by the NZDF.

References

1. Almeida SA, Williams KM, Shaffer RA, Brodine SK. Epidemiological patterns of musculoskeletal injuries and physical training. *Med Sci Sports Exerc.* 1999;31(8):1176-82.
2. Billings CE. Epidemiology of injuries and illnesses during the United States Air Force Academy 2002 Basic Cadet Training program: documenting the need for prevention. *Mil Med*. 2004;169(8):664-70.
3. Defence Health Service Branch. *Australian Defence Force Health Status Report*. Canberra (AUST): Defence Publishing Service, Department of Defence; 2000.
4. Heir T. Musculoskeletal Injuries in Officer Training – One-Year Follow-Up. *Mil Med*. 1998;163(4):229-33.
5. Kaufman KR, Brodine SK, Shaffer RA. Military training-related injuries: surveillance, research, and prevention. *Am J Prev Med.* 2000;18 Suppl 3:54-63.
6. Parkkari J, Kujala UM, Kannus P. Is it possible to prevent sports injuries? Review of controlled clinical trials and recommendations for future work. *Sports Med*. 2001;31(14):985-95.
7. Pope RP, Herbert R, Kirwan JD, Graham BJ. Predicting attrition in basic military training. *Mil Med*. 1999;164(10):710-14.
8. Chisholm J. The Read clinical classification. *Br Med J*. 1990;300(6732):1092.

9. WHO Working Group on Injury Surveillance. *International Classification of External Causes of Injuries (ICECI): Data Dictionary*. Amsterdam (NLD): Consumer Safety Institute; 2001.
10. Knapik J, Ang P, Reynolds K, Jones B. Physical fitness, age, and injury incidence in infantry soldiers. *J Occup Med*. 1993;35(6):598-603.
11. Handoll HH, Rowe BH, Quinn KM, de Bie R. Interventions for preventing ankle ligament injuries (Cochrane Review). In: *The Cochrane Database of Systematic Reviews*, 3, 2001. Oxford (UK): Update Software; 2001.
12. Thacker SB, Stroup DF, Branche CM, Gilchrist J, et al. Prevention of knee injuries in sports – A systematic review of the literature. *J Sports Med Phys Fitness*. 2003;43(2):165-179.
13. Rome K, Handoll HHG, Ashford R. Interventions for preventing and treating stress fractures and stress reactions of bone of the lower limbs in young adults (Cochrane Review). In: *The Cochrane Database of Systematic Reviews*, 2, 2005. Oxford (UK): Update Software; 2005.
14. Lauder TD, Baker SP, Smith GS, Lincoln AE. Sports and physical training injury hospitalizations in the army. *Am J Prev Med.* 2000;18 Suppl 3:118-28.
15. Piantanida NA, Knapik JJ, Brannen S, O'Connor F. Injuries during Marine Corps officer basic training. *Mil Med.* 2000;165(7):515-20.
16. Lincoln AE, Sorock GS, Courtney TK, Wellman HM, et al. Using narrative text and coded data to develop hazard scenarios for occupational injury interventions. *Inj Prev*. 2004;10(4):249-54.
17. Lipscomb HJ, Glazner J, Bondy J, Lezotte D, et al. Analysis of text from injury reports improves understanding of construction falls. *J Occup Environ Med*. 2004;46(11):1166-73.
18. Lloyd DG. Rationale for training programs to reduce anterior cruciate ligament injuries in Australian football. *J Orthop Sports Phys Ther*. 2001;31(11):645-54.
19. Morris JM. Biomechanics of the foot and ankle. *Clin Orthop Relat Res*. 1977(122):10-7.
20. Rodgers MM. Dynamic foot biomechanics. *J Orthop Sports Phys Ther*. 1995;21(6):306-16.
21. DiGiovanni BF, Partal G, Baumhauer JF. Acute ankle injury and chronic lateral instability in the athlete. *Clin Sports Med*. 2004;23(1):1-19.
22. Milgrom C, Shlamkovitch N, Finestone A, Eldad A, et al. Risk factors for lateral ankle sprain: a prospective study among military recruits. *Foot & Ankle Int*. 1991;12(1):26-30.
23. Jordaan G, Schwellnus MP. The incidence of overuse injuries in military recruits during basic military training. *Mil Med*. 1994;159(6):421-6.
24. Smith GS, Dannenberg AL, Amoroso PJ. Hospitalization due to injuries in the military. Evaluation of current data and recommendations on their use for injury prevention. *Am J Prev Med.* 2000;18 Suppl 3:41-53.
25. Bell NS, Mangione TW, Hemenway D, Amoroso PJ, et al. High injury rates among female army trainees: a function of gender? *Am J Prev Med*. 2000;18 Suppl 3:141-6.
26. Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, et al. Risk factors for training-related injuries among men and women in basic combat training. *Med Sci Sports Exerc.* 2001;33(6):946-54.
27. Pope RP, Herbert RD, Kirwan JD, Graham BJ. A randomized trial of preexercise stretching for prevention of lower-limb injury. *Med Sci Sports Exerc*. 2000;32(2):271-7.
28. Jones BH, Bovee MW, Harris JM, Cowan DN. Intrinsic risk factors for exercise-related injuries among male and female army trainees. *Am J Sports Med.* 1993;21(5):705-10.