Descriptive Epidemiology of Musculoskeletal Injuries in Naval Special Warfare Sea, Air, and Land Operators

Mita Lovalekar, PhD; John P. Abt, PhD*; Timothy C. Sell, PhD*; Dallas E. Wood, MEd†; Scott M. Lephart, PhD‡*

ABSTRACT The purpose of this analysis was to describe medical chart reviewed musculoskeletal injuries among Naval Special Warfare Sea, Air, and Land Operators. 210 Operators volunteered (age: 28.1 ± 6.0 years, height: 1.8 ± 0.1 m, weight: 85.4 ± 9.3 kg). Musculoskeletal injury data were extracted from subjects' medical charts, and injuries that occurred during 1 year were described. Anatomic location of injury, cause of injury, activity when injury occurred, and injury type were described. The frequency of injuries was 0.025 per Operator per month. Most injuries involved the upper extremity (38.1% of injuries). Frequent anatomic sublocations for injuries were the shoulder (23.8%) and lumbopelvic region of the spine (12.7%). Lifting was the cause of 7.9% of injuries. Subjects were participating in training when 38.1% of injuries occurred and recreational activity/sports when 12.7% of injuries occurred. Frequent injury types were strain (20.6%), pain/spasm/ache (19.0%), fracture (11.1%), and sprain (11.1%). The results of this analysis underscore the need to investigate the risk factors, especially of upper extremity and physical activity related injuries, in this population of Operators. There is a scope for development of a focused, customized injury prevention program, targeting the unique injury profile of this population.

INTRODUCTION

Injuries and injury-related musculoskeletal conditions are common in military populations.[1–6] Many of these musculoskeletal injuries occur during physical activity, such as sports and physical training.[7–13] Injuries among military personnel also occur because of combat, but disease and nonbattle injuries have accounted for more losses to fighting forces than injuries caused by combat.[14–19]

Valid and reliable injury epidemiology data are required to describe the frequency and extent of injuries among various populations, in the problem definition step of the public health model.[20] Such descriptive epidemiology studies are necessary for medical and human performance personnel working among military populations, to measure and prioritize the need for health care services, including human resources and technology, and health care delivery systems. Injury epidemiology data are also needed for subsequent steps in the public health model as applied to injury prevention, including for the identification of risk factors and protective factors, development and testing of prevention strategies, and implementation and assessment of injury prevention programs.

*Neuromuscular Research Laboratory, Department of Sports Medicine and Nutrition, School of Health & Rehabilitation Sciences, University of Pittsburgh, 3830 South Water Street, Pittsburgh, PA 15203.

†Department of the Navy, Naval Special Warfare, 1300 Helicopter Road, Virginia Beach, VA 23459.

‡University of Kentucky, Charles T. Wethington, Jr. Building, Room 123, Lexington, KY 40536-0200.

Presented in poster format at the American College of Sports Medicine Annual Meeting, May 28–June 1, 2013, Indianapolis, IN.

doi: 10.7205/MILMED-D-14-00655

The Armed Forces Epidemiological Board revealed that injuries have a greater impact on health and military readiness of U.S. Armed Forces than any other medical complaint.[21] Previous studies and publications have addressed the descriptive epidemiology of musculoskeletal injuries in military personnel,[1,4,6] including those in the Army,[5,22–26] Navy,[27] and Marine corps,[28] but more research is needed into the epidemiology of musculoskeletal injuries among Special Operations military personnel. Special Operations personnel in various branches of the military train the hardest and perform difficult duties, and musculoskeletal injuries are also common among them.

Naval Special Warfare (NSW) Sea, Air, and Land (SEAL) Operators are a group of elite NSW tactical athletes.[29,30] NSW SEAL Operators play an essential role in unconventional warfare,[30] and are trained to operate in terrestrial and maritime environments, especially in underwater aquatic missions.[31] Successful completion of operations requires a high level of physical conditioning.[31] Injury and attrition rates among NSW SEAL recruits are high[30,32] with the second most common cause of attrition being medical drops/rollbacks.[33] Epidemiological data regarding musculoskeletal injuries in NSW SEAL Operators is scarce and is often limited to recruit training.[30,33] In a study by Linenger et al among NSW SEAL recruits, there were 29.7 cases of musculoskeletal injuries per 100 trainee-months. More than 75% of these injuries involved the lower limb, and greater than 90% of the musculoskeletal injuries were overuse injuries.[30] Shwayhat et al[33] found an overall incidence of overuse injuries of 3.4 per 1,000 recruit-days among NSW SEAL recruits. Both these studies have described a very high rate of injuries among NSW SEAL recruits. Peterson et al[29] described a rate of about 0.9 to 3.2 injuries per 100 persons per month among NSW SEAL Operators that presented to a clinic. The authors

reported that injuries most frequently affected the back/neck, knee, and shoulder in descending order of occurrence; this anatomic distribution is different from that described in NSW SEAL recruits.

NSW SEAL Operators undergo some of the most arduous physical training in the military devoting more time to training and physical conditioning than many other Special Operations Forces.[31] Given the current paucity of data on musculoskeletal injuries among active duty NSW SEAL Operators, there is a clear need for a comprehensive descriptive epidemiology study in this population, with a description of most common musculoskeletal injuries, anatomic location, injury type, injury cause, and activity when injury occurred. This information can insure that customized, data-driven, injury prevention programs address the most common injuries. The purpose of this study was to describe medical chart reviewed musculoskeletal injuries in a sample of NSW SEAL Operators. The descriptive epidemiology of musculoskeletal injuries in this article includes a description of injury frequency, common injury types, injury anatomic location, injury cause, and activity when injury occurred.

METHODS

Participants

210 Operators volunteered (age = 28.1 ± 6.0 years, height = 1.8 ± 0.1 m, weight = 85.4 ± 9.3 kg). All Operators were male. The Operators were participants in a comprehensive injury prevention and performance optimization research program conducted by the University of Pittsburgh. Operators were informed about our research study, and active duty NSW SEAL Operators, who were between 18 and 45 years of age, with no medical or musculoskeletal conditions that precluded them from full active duty, were invited to participate in the study. All Operators who volunteered were included in the study. The study subjects were recruited during 2008 to 2013, and consisted of experienced as well as new Operators. The comprehensive research program consisted of laboratory testing at the University of Pittsburgh Neuromuscular Research Laboratory at the NSW installation, and included a review of Operators' medical charts. Human subject protection approval was obtained from the University of Pittsburgh's Institutional Review Board. All Operators provided written informed consent forms before participation.

Medical Chart Review

A detailed musculoskeletal injury history was obtained from the Operator's paper medical charts maintained locally by medical personnel within respective units. Medical charts were reviewed by members of the research team, and data about musculoskeletal injuries and related musculoskeletal conditions (henceforth referred to as injury in this manuscript) were extracted. Medical chart reviews were performed during 2008 to 2013. Data obtained from medical chart review were entered into a customized database.

For the purposes of this analysis, a musculoskeletal injury was defined as an injury to the musculoskeletal system (bones, ligaments, muscles, tendons, etc.) for which medical care was sought. This includes conditions such as sprains, strains, and fractures, but not contusions or lacerations.

Statistical Analyses

This article includes a description of medical chart reviewed injuries sustained during the calendar year before the year of laboratory testing. Anatomic location of injuries was classified as lower extremity, upper extremity, spine, torso, or head/face. Lower extremity injuries were further classified into injuries affecting one of six anatomic sublocations—hip, knee, ankle, thigh, lower leg, and foot and toes. Upper extremity injuries were further classified as injuries affecting one of six anatomic sublocations—shoulder, elbow, wrist, upper arm, forearm, and hand and fingers. Injuries affecting the spine were classified into the following sublocations—cervical spine, thoracic spine, lumbopelvic spine, and other spine. Torso injuries were classified as chest or abdomen injuries.

Injuries were described using relative frequency (percent). Description of injuries included calculation of injury percent in each category.

RESULTS

Medical charts were available and reviewed for 210 Operators. A total of 63 injuries were recorded in the medical charts during a 1-year period. The average numbers of injuries recorded per Operator were 0.025 injuries per month. 31 Operators (31/210, 14.8%) had one injury, 10 Operators (10/210, 4.8%) had two injuries, 1 Operator (1/210, 0.5%) had three injuries, 1 Operator (1/210, 0.5%) had four injuries, and 1 Operator (1/210, 0.5%) had five injuries, during a 1-year period. 166 Operators (166/210, 79.0%) did not have any injuries recorded in their medical charts during a 1-year period.

Anatomic locations and sublocations of injuries were analyzed to describe common anatomic locations for the musculoskeletal injuries. Figure 1 is an illustration of the anatomic location of injuries. The upper extremity (24/63, 38.1% of injuries) was the most common anatomic location for injuries, followed by the lower extremity (22/63, 34.9% of injuries).

Table I includes a detailed description of anatomic sublocations of the injuries. The shoulder was the most frequent anatomic sublocation (15/63, 23.8% of the injuries), followed by the lumbopelvic region of the spine (8/63, 12.7% of injuries).

Table II includes a description of the cause of injuries. Lifting was the cause of 7.9% of the injuries, direct trauma was the cause of 6.3% of injuries, and falls were the cause of 6.3% of injuries. Medical charts did not contain information about injury cause for a large proportion of injuries (60.3%).

Figure 2 illustrates the activity subjects were participating in when the injury occurred. As expected, a large proportion of injuries occurred during training or recreational activity/

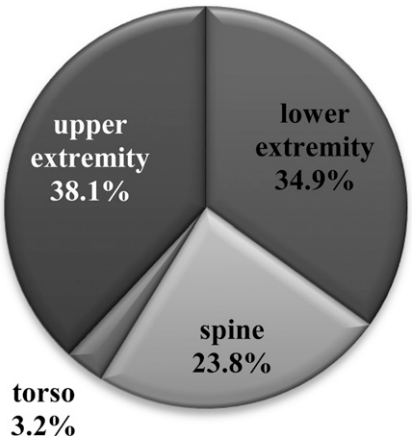


FIGURE 1. Anatomic location of injuries (number of injuries = 63, relative frequency, during a 1-year period), among Naval Special Warfare Sea, Air, and Land Operators.

sports. Subjects were engaged in training when the injury occurred in the case of 24 injuries (24/63, 38.0%), and subjects were engaged in recreational activity/sports at the time of 8 injuries (8/63, 12.7%). Similar to injury cause, data about activity when injury occurred were missing for a large proportion (22.2%) of medical chart reviewed injuries.

A description of injury types is included in Table III. When ranked by frequency of occurrence, strains were the most frequent injury type (13/63, 20.6%), and fractures and sprains each made up 11.1% of injuries (7/63 injuries). 12 injuries (12/63, 19.0%) were identified as pain/spasm/ache in the medical charts, without further elaboration of pathology.

DISCUSSION

This article contains the descriptive epidemiology of medical chart reviewed musculoskeletal injuries among a sample of NSW SEAL Operators. Most of the injuries in the current study affected the extremities. This anatomic distribution was different from medical record data reported among NSW SEAL recruits,[30,33] or previously reported among NSW SEAL Operators.[29] The majority of musculoskeletal injuries in the current study occurred during training or recreational activity/sports. These findings suggest that there may be a need to evaluate the prescribed as well as self-imposed training regimen followed by active duty Operators, and also to educate Operators on strategies to prevent musculoskeletal injuries during recreational and sports activities.

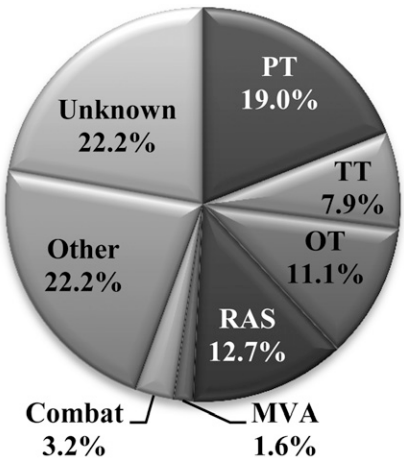
A few previous studies have described the burden of musculoskeletal injuries among NSW SEAL trainees. A study by

TABLE I. Anatomic Sub-Location of the Injuries (During a 1-year Period), Among Naval Special Warfare Sea, Air, and Land Operators

Injury Anatomic Location	Injury Anatomic Sub-Location	Number of Injuries	Percentage of Injuries
Upper Extremity	Upper Arm	2	3.2
	Forearm	3	4.8
	Shoulder	15	23.8
	Wrist	1	1.6
	Hand and Fingers	3	4.8
Lower Extremity	Thigh	5	7.9
	Lower Leg	3	4.8
	Knee	5	7.9
	Ankle	6	9.5
	Foot and Toes	3	4.8
Spine	Cervical	3	4.8
	Thoracic	4	6.3
	Lumbopelvic	8	12.7
Torso	Chest	2	3.2
Total		63	

TABLE II. Cause of the Injuries (During a 1-year Period), Among Naval Special Warfare Sea, Air, and Land Operators

Injury Cause	Number of Injuries	Percentage of Injuries
Lifting	5	7.9
Direct Trauma	4	6.3
Fall	4	6.3
Crushing	3	4.8
Landing	2	3.2
Running	1	1.6
Other	6	9.5
Unknown	38	60.3
Total	63	



PT: Physical training

TT: Tactical training

OT: Other/unspecified training

RAS: Recreational Activity/Sports

MVA: Motor Vehicle Accident

FIGURE 2. Activity when injuries occurred (number of injuries = 63, during a 1-year period), among Naval Special Warfare Sea, Air, and Land Operators.

TABLE III. Injury Types and Rank by Frequency (During a 1-year Period), Among Naval Special Warfare Sea, Air, and Land Operators

Rank	Injury Type	Number of Injuries	Percentage of Injuries
1	Strain	13	20.6
2	Pain/Spasm/Ache	12	19.0
3	Fracture	7	11.1
4	Sprain	7	11.1
5	Tendonitis/Tenosynovitis/ Tendinopathy	6	9.5
6	Impingement	3	4.8
8	Bursitis	2	3.2
9	Inflammation	2	3.2
11	Chondromalacia/Patellofemoral Pain	1	1.6
12	Degenerative Joint Disease	1	1.6
13	Disc Injury	1	1.6
14	Labral Tear	1	1.6
15	Nerve	1	1.6
16	Stress Fracture	1	1.6
10	Other	2	3.2
7	Unknown	3	4.8
	Total	63	

Linenger et al[30] recorded patient encounters at the medical clinic during SEAL candidates training, excluding a period of intense training called "Hell Week," using a specially designed computer-based data collection system. Data were coded using the International Classification of Disease, Clinical Modification, 9th edition code (ICD-9-CM). Shwayhat et al[33] looked at overuse injuries among NSW SEAL recruits during Basic Underwater Demolition/SEAL (BUD/S) training. Data were coded using the ICD-9 coding system. The frequency of musculoskeletal injuries in the study by Linenger et al[30] was 29.7 cases per 100 trainee-months, although in the study by Shwayhat et al,[33] it was 3.4 overuse injuries per 1,000 recruit-days. The frequency of injuries was much higher in the 2 studies among NSW SEAL recruits, as compared to the current study among NSW SEAL Operators. The injury frequency in the study by Linenger et al may have been even higher if injuries that occurred during "Hell Week" were also included. The studies by Linenger et al and Shwayhat et al were conducted among NSW SEAL recruits, whereas the current study was conducted among active duty SEAL Operators. It is possible that NSW SEAL recruits are at a higher risk of suffering from musculoskeletal injuries, since the training of SEAL recruits is physically demanding.

In the study by Linenger et al, over three-quarters musculoskeletal injuries involved the lower limb. In comparison, the most frequent anatomic location for injuries in the current study was the upper extremity (38.1% of injuries). In the study by Linenger et al, common injury diagnoses were from overuse—iliotibial band syndrome, patellofemoral syndrome, and stress fracture, and in the study by Shwayhat et al the 3 most common overuse injuries were stress fractures, sprains/strains, and iliotibial band syndrome. Though strain was a frequent injury type in the current study (20.6% of injuries), stress fractures were not common (1.6% of injuries). These differences in injury anatomic location and injury types seen when comparing the current study with the two previous studies,[30,33] are probably the result of describing injuries during two distinct phases of a NSW subject's career (SEAL Operators and SEAL recruits, respectively), and different methods of obtaining injury data (medical chart review and ICD-9 coded patient encounter data, respectively).

Kaufman et al[34] investigated the effect of foot structure and range of motion on overuse injuries among NSW SEAL candidates during training at the Basic Underwater Demolition/SEAL School. Subjects were observed during their 25-week formal training period. There were 348 lower extremity overuse injuries among 449 enrollees, during the 25 weeks period of prospective follow up, or 13.4 lower extremity overuse injuries per 100 subjects per month. The injury rate among NSW SEAL recruits described in the article by Kaufman et al was much higher than that in the current study among NSW SEAL Operators (0.025 injuries per subject per month).

The current study measured the frequency of injuries among active duty NSW SEAL Operators based on medical chart records. A similar study by Peterson et al[29] also used injury data extracted from medical records generated during clinic visits. The incidence of injuries in the study by Peterson et al was expressed as a range (0.9–3.2 injuries per 100 subjects per month). The upper end of this range is closer to the frequency measured in the current study (0.025 medical chart reviewed injuries per subject per month). The distribution of injuries by anatomic location and injury type is different between the study by Peterson et al and the current study. In the study by Peterson et al, the most common anatomic location of injuries was the back/neck (20.9% of the visits) and the most frequent diagnosis was shoulder bursitis or impingement (9.3% of the visits). The study by Peterson et al counted each individual clinic visit rather than each injury, so it is likely that greater weight was given to injuries that required multiple clinic visits when calculating proportions for anatomic locations and injury types.

A report published by the Naval Health Research Center described self-reported injuries among NSW Special Boat Units 12, 20, and 22 Operators.[35] Subjects in this study completed the Special Boat Unit Injury Survey, which included questions about injury history. The frequency of self-reported injuries among the Special Boat Operators was 0.018 injuries per person per month, which was lower than the frequency of injuries in the current study among NSW SEAL Operators. The most common type of injury in the Special Boat Operators was sprain/strain and the most common injury site was the low back. Based on data about when the injury occurred, 94.8% of the injury events occurred while performing job related tasks. The tasks performed by NSW Special Boat Units Operators are different from the tasks performed by NSW SEAL Operators and the data were

self-reported, which may explain the difference in the injury anatomic location between this and the current study. Descriptive epidemiology studies have been conducted among Special Operation Forces in other branches of the military. A study by Hollingsworth,[36] among members of a Marine Special Operations Battalion, utilized self-reported injury history to describe the burden of injuries in this population. 32% of the subjects reported musculoskeletal pain or physical limitations, and the injury frequency was about 0.039 injuries per subject per month, which is higher than the injury frequency in the current study (0.025 injuries per month). Among those who reported being injured, almost 30.0% said that their ability to train was adversely impacted by their injury. These studies underscore the burden of musculoskeletal injuries among Special Operation Forces in the military. Many of these injuries are potentially preventable.

A study conducted among U.S. Special Operations Forces Soldiers by our group,[37] found an injury frequency of 0.020 injuries per subject per month, which is approximately similar to the injury frequency in the current study (0.025 injuries per month), but is lower than the injury frequency reported among other U.S. Special Operations Forces.[35,36] The current study and our previous study among U.S. Special Operations Forces Soldiers, were both part of a comprehensive injury prevention and performance optimization research program. The program included laboratory testing, and to meet inclusion and exclusion criteria, Operators with serious injury were likely excluded from the sample. Because of this, the current study may be underestimating the true injury frequency, since our study participants were healthy and active duty NSW SEALs.

As part of the comprehensive injury prevention and performance enhancement research program, a study was also conducted by our group among the U.S. Army 101st Airborne Division (Air Assault).[22] This study revealed an injury frequency of 0.030 injuries per subject per month, which is approximately equal to that found in the current study. A study of musculoskeletal injuries among the 82nd Airborne Division at Fort Bragg, using medical chart data, found an injury rate of 97 per 1,000 soldier months.[25] The injury frequency reported in the current article was lower than the rate reported among the 82nd Airborne Division. A study by Hauret et al[3] of nondeployed active duty military service members during the year 2006, reported an injury rate of 628 injuries per 1,000 person years, which is slightly higher than the current study. There was a difference in the way injuries were counted in the current study, as compared to the Hauret study where ICD-9-CM coded data were used. Some chronic injuries that lasted for a period greater than 60 days could have been counted more than once.

The majority of musculoskeletal injuries in the current study occurred during training or recreational activity/sports. The risk of musculoskeletal injury increases with increasing amounts of physical activity.[38] It has been suggested that there may be a threshold above which the risk of injury may outweigh the fitness benefits of physical activity.[39]

Limitations of the Present Study

Medical charts contain injury data only for injuries where medical care was sought. As a consequence medical records can have incomplete data especially for self perceived minor injuries,[40,41] as well as certain injury types such as back pain.[42] Some military personnel may not seek medical care, even for injuries that can limit performance and increase the risk of injury recurrence.[33,35,43]

CONCLUSIONS

Among the Operators who participated in this study, the majority of musculoskeletal injuries occurred during training or recreational activity/sports, and affected predominantly the upper extremity, especially the shoulder. The high proportion of injuries that occur during physical activity requires evaluation of the prescribed as well as self-imposed training regimen followed by active duty Operators, and education of Operators on strategies to reduce potentially preventable injuries such as strain, sprain, and tendonitis. There is a need to investigate the risk factors, and develop a focused, customized injury prevention program, especially for upper extremity and physical activity-related injuries. Future research focusing on the impact of these injuries on injury recurrence, tactical readiness and attrition, is also needed.

ACKNOWLEDGMENT

We would like to thank those Operators who participated in this study. This work was supported by the Office of Naval Research number N00014-11-1-0929.

REFERENCES

1. Armed Forces Health Surveillance Center (AFHSC). Hospitalizations among members of the active component, U.S. Armed Forces, 2009. MSMR 2010; 17(4): 3–9.
2. Sanders JW, Putnam SD, Frankart C, et al: Impact of illness and noncombat injury during Operations Iraqi Freedom and Enduring Freedom (Afghanistan). Am J Trop Med Hyg 2005; 73(4): 713–9.
3. Hauret KG, Jones BH, Bullock SH, Canham-Chervak M, Canada S: Musculoskeletal injuries description of an under-recognized injury problem among military personnel. Am J Prev Med 2010; 38(1 Suppl): S61–70.
4. Armed Forces Health Surveillance Center (AFHSC). Absolute and relative morbidity burdens attributable to various illnesses and injuries, U.S. Armed Forces, 2009. MSMR 2010; 17(4): 16–21.
5. Smith TA, Cashman TM: The incidence of injury in light infantry soldiers. Mil Med 2002; 167(2): 104–8.
6. Armed Forces Health Surveillance Center (AFHSC). Ambulatory visits among members of the active component, U.S. Armed Forces, 2009. MSMR 2010; 17(4): 10–5.
7. Lauder TD, Baker SP, Smith GS, Lincoln AE: Sports and physical training injury hospitalizations in the army. Am J Prev Med 2000; 18(3 Suppl): 118–28.
8. Jacobs JM, Cameron KL, Bojescul JA: Lower extremity stress fractures in the military. Clin Sports Med 2014; 33(4): 591–613.
9. Cameron KL, Owens BD: The burden and management of sports-related musculoskeletal injuries and conditions within the US military. Clin Sports Med 2014; 33(4): 573–89.
10. Molloy JM, Feltwell DN, Scott SJ, Niebuhr DW: Physical training injuries and interventions for military recruits. Mil Med 2012; 177(5): 553–8.

11. Kaufman KR, Brodine S, Shaffer R: Military training-related injuries: surveillance, research, and prevention. Am J Prev Med 2000; 18(3 Suppl): 54–63.
12. Ruscio BA, Jones BH, Bullock SH, et al: A process to identify military injury prevention priorities based on injury type and limited duty days. Am J Prev Med 2010; 38(1 Suppl): S19–33.
13. Bullock SH, Jones BH, Gilchrist J, Marshall SW: Prevention of physical training-related injuries recommendations for the military and other active populations based on expedited systematic reviews. Am J Prev Med 2010; 38(1 Suppl): S156–81.
14. Cohen SP, Brown C, Kurihara C, Plunkett A, Nguyen C, Strassels SA: Diagnoses and factors associated with medical evacuation and return to duty for service members participating in Operation Iraqi Freedom or Operation Enduring Freedom: a prospective cohort study. Lancet 2010; 375(9711): 301–9.
15. Headquarters, Department of the Army. Preventive Medicine Servcies. Field Manual No. 4-02.17, 2000. Available at http://www.fas.org/irp/doddir/milmed/prevserv.pdf; accessed October 11, 2013.
16. Croft AM, Hoad NA, Dale RF: Hospitalization of British troops during Operation Joint Endeavor (Bosnia). Mil Med 1999; 164(7): 460–5.
17. Champion HR, Bellamy RF, Roberts CP, Leppaniemi A: A profile of combat injury. J Trauma 2003; 54(5 Suppl): S13–9.
18. Palinkas LA, Coben P: Disease and non-battle injuries among U.S. Marines in Vietnam. Mil Med 1988; 153(3): 150–5.
19. Zouris JM, Wade AL, Magno CP: Injury and illness casualty distributions among U.S. Army and Marine Corps personnel during Operation Iraqi Freedom. Mil Med 2008; 173(3): 247–52.
20. Powell EC, Sheehan KM, Christoffel KK: Firearm violence among youth: public health strategies for prevention. Ann Emerg Med 1996; 28(2): 204–12.
21. Jones BH, Hansen BC: An armed forces epidemiological board evaluation of injuries in the military. Am J Prev Med 2000; 18(3 Suppl): 14–25.
22. Sell TC, Abt JP, Crawford K, et al: Warrior model for human performance and injury prevention: eagle tactical athlete program (ETAP) part I. J Spec Oper Med 2010; 10(4): 2–21.
23. Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN: Epidemiology of injuries associated with physical training among young men in the army. Med Sci Sports Exerc 1993; 25(2): 197–203.
24. Jones BH, Bovee MW, Harris JM 3rd, Cowan DN: Intrinsic risk factors for exercise-related injuries among male and female army trainees. Am J Sports Med 1993; 21(5): 705–10.
25. Potter RN, Gardner JW, Deuster PA, Jenkins P, McKee K Jr, Jones BH: Musculoskeletal injuries in an Army airborne population. Mil Med 2002; 167(12): 1033–40.
26. 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.
27. Shaffer RA, Brodine SK, Ito SI, Le AT: Epidemiology of illness and injury among U.S. Navy and Marine Corps female training populations. Mil Med 1999; 164(1): 17–21.
28. Shaffer RA, Brodine SK, Almeida SA, Williams KM, Ronaghy S: Use of simple measures of physical activity to predict stress fractures in young men undergoing a rigorous physical training program. Am J Epidemiol 1999; 149(3): 236–42.
29. Peterson SN, Call MH, Wood DE, Unger DV, Sekiya JK: Injuries in naval special warfare sea, air, and land personnel: epidemiology and surgical management. Oper Tech Sports Med 2005; 13: 131–5.
30. Linenger JM, Flinn S, Thomas B, Johnson CW: Musculoskeletal and medical morbidity associated with rigorous physical training. Clin J Sport Med 1993; 3(4): 229–34.
31. Prusaczyk WK, Stuster JW, Goforth H, Smith TS, Meyer LT: Physical Demands of U.S. Navy Sea-Air-Land (SEAL) Operations. Naval Health Research Center, San Diego, 1995. Available at www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA304895; accessed March 15, 2015.
32. Braun DE, Prusaczyk WK, Goforth HW, Pratt NC: Personality Profiles of U.S. Navy Sea-Air-Land (SEAL) Personnel. Naval Health Research Center, San Diego, 1994. Available at www.dtic.mil/dtic/tr/fulltext/u2/a281692.pdf; accessed March 15, 2015.
33. Shwayhat AF, Linenger JM, Hofherr LK, Slymen DJ, Johnson CW: Profiles of exercise history and overuse injuries among United States Navy Sea, Air, and Land (SEAL) recruits. Am J Sports Med 1994; 22(6): 835–40.
34. Kaufman KR, Brodine SK, Shaffer RA, Johnson CW, Cullison TR: The effect of foot structure and range of motion on musculoskeletal overuse injuries. Am J Sports Med 1999; 27(5): 585–93.
35. Ensign W, Hodgdon JA, Prusaczyk WK, Shapiro D, Lipton M: A Survey of Self-Reported Injuries Among Special Boat Operators. Naval Health Research Center, San Diego, 2000. Available at www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA421234; accessed March 15, 2015.
36. Hollingsworth DJ: The prevalence and impact of musculoskeletal injuries during a pre-deployment workup cycle: survey of a Marine Corps special operations company. J Spec Oper Med 2009; 9(4): 11–5.
37. Abt JP, Sell TC, Lovalekar MT, et al: Injury epidemiology of U.S. Army Special Operations forces. Mil Med 2014; 179(10): 1106–12.
38. Jones BH, Cowan DN, Knapik JJ: Exercise, training and injuries. Sports Med 1994; 18(3): 202–14.
39. Colbert LH, Hootman JM, Macera CA: Physical activity-related injuries in walkers and runners in the aerobics center longitudinal study. Clin J Sport Med 2000; 10(4): 259–63.
40. Valuri G, Stevenson M, Finch C, Hamer P, Elliott B: The validity of a four week self-recall of sports injuries. Inj Prev 2005; 11(3): 135–7.
41. Bardehle D, Fuhr A, Monárrez-Espino J, Heyer C-M, Rössler G: Home and leisure accidents in Europe: survey and hospital data. Inj Control and Saf Promot 2002; 8(4): 251–68.
42. Carragee EJ, Cohen SP: Lifetime asymptomatic for back pain: the validity of self-report measures in soldiers. Spine (Phila Pa 1976) 2009; 34(9): 978–83.
43. Lynch JH, Pallis MP: Clinical diagnoses in a special forces group: the musculoskeletal burden. J Spec Oper Med 2008; 8(2): 76–80.