Musculoskeletal Injury in Reserve Officers' Training Corps

A Report From the Athletic Training Practice-Based Research Network

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Background: Reserve Officers' Training Corps (ROTC) cadets must meet the same physical standards as active duty military servicemembers and undergo organized physical training (PT). ROTC participation, like all physical activity, can result in training-related musculoskeletal injury (MSKI), and of course, cadets could sustain MSKI outside of ROTC. However, MSKI incidence in ROTC programs is largely unknown.

Purpose: To describe patient and injury demographics of MSKI in 5 universities' Army ROTC programs.

Study Design: Descriptive epidemiology study.

Methods: A retrospective chart review of electronic medical records was performed using the Athletic Training Practice-Based Research Network (AT-PBRN). Athletic trainers at 5 clinical practice sites within the AT-PBRN documented injury assessments via a web-based electronic medical record system. Medical records during the 2017-2018 and 2018-2019 academic years were used for analysis. Summary statistics were calculated for age, sex, height, body mass, military science year, training ability group, mechanism of injury, activity type associated with injury, anatomic location of injury, participation status, injury severity, and diagnosis.

Results: A total of 364 unique injuries were documented. Cadets in the most advanced fitness group (Alpha; n = 148/364) and in their third year of training (n = 97/364) presented with the most injuries. Injuries most commonly occurred during PT (n = 165/364). Insidious onset (n = 146/364) and noncontact (n = 115/364) mechanisms of injury were prevalent. The most frequent anatomic location of injury was the knee (n = 71/364) followed by the ankle (n = 57/364). General sprain/strain was the most frequent International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis code reported (n = 34/364).

Conclusion: The knee was the most frequent location of MSKI in ROTC participants, and most MSKIs had insidious onset. Cadets with higher injury frequency were high achieving (Alpha) and in a critical time point in ROTC (military science year 3). The majority of MSKIs can be attributed to ROTC training, with PT being the most frequent activity associated with injury. Civilian health care providers, from whom ROTC cadets will most likely seek medical attention, need to be aware of ROTC physical demands as well as the characteristics of training-related injuries.

Keywords: military training; neuromusculoskeletal injury; military injury; overuse injury; tactical athlete

The impact of musculoskeletal injuries (MSKIs) on military medical costs, limited duty days, and military readiness has been well-documented.[11,12,20] Cases of MSKI were responsible for >75% of all medically nondeployable classifications in 2015.[2] In addition to the impact on active-duty military members, initial-entry training MSKIs are financially burdensome, particularly if training is prolonged or trainees are discharged due to injury.[5,10] A high rate of initial-entry MSKI creates fiscal strain,[5,10] decreases physical readiness at first duty stations,[21] and elevates a servicemember's future injury risk.[8,13] The identification and reduction of MSKI during initial-entry military training is of great importance, because a history of MSKI increases the risk for future MSKI development.[8,13]

During basic combat training for enlisted servicemembers, 43% of trainees sustained a documented MSKI during training.[5] The majority of US Army trainees begin initial-entry training with basic combat training; however, there are multiple initial-entry training routes. Differences in initial-entry training routes may make a difference in

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MSKI incidence; within the Marine Corps, rates of MSKI differ between enlisted Marines and officer candidate initial-entry training.[17,22] The US military academies are a well-known officer initial-entry training route, in which cadets have a 23.2% risk of lower extremity MSKI.[14] However, other officer initial-entry training paths exist, and MSKI rates have been found to differ between officer candidate initial-entry training routes.[19]

Reserve Officers' Training Corps (ROTC) is the largest commissioning body of army officers,[3] yet injury patterns in ROTC cadets are largely unknown. Cadets are full-time college students who are attached to a university's ROTC program for initial-entry officer training. Active duty army members serve as the program's leadership (cadre) and provide oversight during the military training that occurs over the course of the cadet's college education. Cadets must maintain Army physical fitness standards before being commissioned as a second lieutenant upon graduation.[3] One study,[23] using a single university's ROTC program, reported a lower extremity MSKI incidence rate of 60 per 100 person-years during ROTC physical training (PT). This study provides an initial evaluation of this unique population. Although national standards must be maintained, each individual ROTC program's cadre has autonomy regarding cadets' development and establishment of the program's culture. Military leadership has been previously found to influence MSKI rates[5] and reporting.[6] Multiple ROTC programs must be evaluated to provide a comprehensive evaluation of MSKI in ROTC. Therefore, the current study aimed to describe MSKIs reported in 5 university Army ROTC programs that had access to athletic training medical care.

METHODS

Design and Setting

The current study was a retrospective chart review of deidentified patient data compiled via a web-based electronic medical records (EMR) system. The CORE-AT EMR is managed via the Athletic Training Practice-Based Research Network (AT-PBRN) and housed at A.T. Still University. The AT-PBRN is an Agency for Healthcare Research and Quality–affiliated, practiced-based research network,[4] whose standards and procedures for using EMR data for research purposes have been previously defined and used for publication.[15,16,24] This study was deemed exempt by the universities' institutional review boards.

The retrospective chart review was performed for the 2017-2018 (year 1) and 2018-2019 (year 2) academic years, approximately August through May. Onset and cessation of organized ROTC activities were dependent on each university's academic calendar. Of the 5 programs, 4 programs held organized PT 3 days a week during the academic year, whereas 1 program held organized PT 4 days a week. The incidence of field exercise training, land navigation, ruck marches, and nontraditional PT sessions varied by program and was at the discretion of each program's leadership.

Participating ROTC Clinical Practice Sites

Characteristics of the ROTC programs and athletic training involvement are included in Table 1. For year 1, we examined 5 universities' ROTC programs with athletic training medical care. A total of 457 cadets were enrolled in ROTC at 1 of the 5 programs evaluated during year 1. For year 2, we examined 4 ROTC programs, with a total of 465 enrolled cadets, due to the loss of certified athletic trainer (AT) funding at 1 university.

All ROTC programs had access to an AT during organized morning PT sessions as well as access to additional AT medical care during either structured or as-needed clinical appointments. Most ATs were female (5 females, 3 males) and employed as graduate assistants working toward a master's degree (Table 1). All included MSKI diagnoses were made by an AT working with the ROTC program or by a cadet or cadre member's personal medical provider (eg, physician, physician's assistant, nurse practitioner) and subsequently reported to the AT for documentation and treatment.

Data Collection

Data were collected from all EMR medical documentation created by ATs who were members of the AT-PBRN during the study timeframe. Before using the EMR, ATs were required to complete a 2-hour training session on the use of the EMR to ensure data quality.[24] After the training session, ATs were able to use the EMR to document all aspects of routine patient care, including injury evaluation, daily treatment, and discharge summaries.

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TABLE 1
ROTC Research Site Demographics[a]

	Battalion 1	Battalion 2	Battalion 3	Battalion 4	Battalion 5
University Carnegie classifications					
Size classification	Large	Medium	Large	Large	Large
Basic (research) classification	Very high research activity	Master's colleges and universities: large	Very high research activity	Very high research activity	High research activity
No. of enrolled cadets					
2017-2018	72	98	185	70	32
2018-2019	134	Not applicable[b]	190	81	60
Characteristics of AT involvement					
Years of AT involvement	9	8	7	2	1
No. of ATs	2	1	2	1	2
Position classification	Graduate assistant	Faculty volunteer	Graduate assistant	Graduate assistant	Graduate assistant
Funding source	Teaching assistantship	None, gift in kind service	Indirect funds	Internal grant funding	Teaching assistantship

[a]Carnegie classifications refer to the classification system for colleges and universities in the United States based upon a standard of metrics, including enrollment, degrees conferred, and research activity. AT, certified athletic trainer; ROTC, Reserve Officers' Training Corps.
[b]Loss of AT position funding for the 2018-2019 academic year.

Instrumentation

The CORE-AT EMR (www.core-at.com) is a web-based, Health Insurance Portability and Accountability Act–compliant patient documentation system that has been described in detail in previous studies.[15,16,24] A Certification of Honest Broker System/Processes provided by the EMR developer (Ripple Group) ensures that patient data obtained by the AT-PBRN are deidentified following federal regulation and guidelines.[7] Before the 2017-2018 academic year, the EMR was modified, in consultation with all 5 research sites, to include military specific classifications, mechanisms of injury, activities, and fitness assessments unique to this setting.

The current study reviewed data from the injury demographic form within the EMR. The injury demographic form includes age, sex, height, body mass, military science year (which indicates progression within the ROTC program), ability group (which indicates fitness level based on the army's physical fitness test), mechanism of injury, activity type associated with injury (PT, field experience training, nonsanctioned activity), anatomic location of injury, participation status, injury severity, and diagnosis (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] orthopaedic and illness diagnosis codes).[24] For quality assurance purposes, patient data were collected as structured variables (ie, drop-down menus, radio buttons) within the EMR. All patient data categorization was performed by the clinical site AT, including injury severity and participation status. Injury severity options included mild, moderate, and severe (based on clinical judgment) and first-, second-, and third-degree options typically associated with sprains and strains. Participation status included options related to difficulties in activities (eg, difficulties with daily activities, difficulties with ROTC activities, difficulties with both ROTC and daily activities, and no difficulties), participation classifications traditionally associated with sports (eg, no restrictions, noncontact only, light contact), and an option for "other restrictions" (eg, unable to perform push-ups due to upper extremity injury but allowed to perform lower body PT exercises).

Data Analysis

Data were collected on each MSKI's unique injury demographic form within the EMR, not each individual cadet.[16] For example, a lateral ankle sprain and a rotator cuff tendinopathy, even if in the same individual, were documented as unique MSKIs (2 MSKIs total). Data from all research sites during the study time period were combined for analysis and are reported as aggregate findings. Descriptive statistics and frequencies were calculated and reported for all variables of interest. Analyses were completed using SPSS (Version 24; IBM Corp).

RESULTS

MSKIs documented between August 1, 2017, and May 30, 2019, were included in this report. A total of 364 MSKIs were reported over the course of the 2-year study period. MSKIs were reported in patients who were primarily male (214 males, 150 females), 20.84 ± 4.85 years old, 126.82 ± 76.52 cm tall, with a body mass of 65.31 ± 28.20 kg. Frequencies of ability group and military science (MS) year reported at the time of MSKI are presented in Table 2.

TABLE 2
Musculoskeletal Injury Patient Characteristics (N = 364)

	Frequency, n	Percentage
Military science (MS) year		
MS 1	78	21.4
MS 2	68	18.7
MS 3	97	26.6
MS 4	51	14.0
Other or unknown	70	19.2
Training ability group		
Alpha	148	40.7
Bravo	55	15.1
Charlie	17	4.7
Delta	21	5.8
Cadre	8	2.2
Other or unknown	115	31.6

TABLE 3
Musculoskeletal Injury Characteristics (N = 364)[a]

	Frequency, n	Percentage
Anatomic location		
Knee	71	19.5
Ankle	57	15.7
Shoulder	44	12.1
Calf	42	11.5
Back	35	9.6
Hip	30	8.2
Thigh	26	7.1
Foot	22	6.0
Neck	8	2.2
Trunk	5	1.4
Wrist	5	1.4
All other anatomic locations	19	5.2
Mechanism of injury		
Insidious onset	146	40.1
Noncontact	115	31.6
Fall	32	8.8
Twisting	29	8.0
Ruck march	27	7.4
Contact	12	3.3
Fall from height	3	0.8
Activity during injury		
PT	165	45.3
Non-ROTC related	93	25.5
Ruck march	18	4.9
Nontraditional ROTC PT	10	2.7
Field training exercise	6	1.6
Land navigation	4	1.1
Obstacle course	3	0.8
Confidence course	1	0.3
Informal conditioning	11	3.0
Other	25	6.9

[a]PT, physical training; ROTC, Reserve Officers' Training Corps.

The 11 most common injury diagnoses, in order of frequency, were general sprain/strain (34/364); sprain/strain of the thigh, hip, or groin (33/364); low back pain (26/364); knee pain (22/364); anterior/posterior tibialis tendinitis (17/364); quadriceps strain (16/364); sprain/strain of the distal thigh (14/364); iliotibial band syndrome (13/364); shoulder pain (13/364); sprain/strain of the neck (9/364); and patellar tendinitis (9/364). Data regarding anatomic location of injury, mechanism of injury, and activity during injury are presented in Table 3. Injury severity and participation status are presented in Table 4.

DISCUSSION

The current study aimed to characterize MSKIs in ROTC programs with access to AT medical care. Findings from the 364 MSKIs documented over the 2-year study indicate that MSKI demographics in ROTC are similar to those reported in other initial-entry training routes and military populations. The knee was most frequent location of injury (19.5%), followed by the ankle (15.7%) and shoulder (12.1%). The knee is also the most frequently injured site for training-related injuries acquired during army basic training (20%).[9] In the basic training population, the hip was the second most common injury site (14%), followed by the ankle (12%).[9] In our ROTC population, hip injuries were less common at 8.2% and ranked sixth in our list of most common anatomic locations of injury. Our findings are similar to an active duty army infantry population, as their most common injury sites are the knee (19.2%) and ankle (14.8%).[5]

Mechanisms of injury in the ROTC population were primarily insidious onset (40.1%) (eg, overuse MSKI) and noncontact (31.6%) (eg, inversion ankle sprain). This finding supports the well-documented prevalence of overuse injuries in both initial-entry training and active duty populations.[5,9,12,13] The most common ICD-9-CM code reported in the current study was that of general sprain/strain (9.3%). This differs from army enlistee initial-entry training populations, where the majority of injuries were classified as "musculoskeletal tissue damage, other" using International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes.[9] However, diagnoses of sprains and strains, using ICD-10-CM codes, are the most common reason for medical profiles in active duty infantry members,[5] which is more similar to the ICD-9-CM diagnosis code findings in the current study.

Physical training was the most common activity attributed to injury (45.3%) in ROTC. In active duty populations, running for PT is the most common injury-inducing activity (32%).[5] The vast majority of injuries in the current study (74.5%) can be attributed to ROTC. Cadets are likely financially responsible for the medical costs of MSKIs acquired during ROTC training. Unlike active duty military, most ROTC cadets are not covered under Tricare for medical insurance purposes. Cadets in our study had access to athletic training medical care, which likely defrayed medical costs to the cadet. However, it is unknown what medical care is being used in other ROTC cadet populations who sustain ROTC training-related injuries. Future studies should evaluate injury incidence and medical care in ROTC programs without direct access to athletic training medical care.

TABLE 4
Musculoskeletal Injury Impact (N = 364)[a]

	Frequency, n	Percentage
Participation status		
No restrictions	133	36.5
Noncontact only	14	3.8
Light contact only	15	4.1
Other restrictions	98	26.9
No participation	85	23.4
Difficulties with daily activities	5	1.4
Difficulties with ROTC activities	5	1.4
Difficulties with ROTC and daily activities	2	0.5
No difficulties	6	1.6
Other	1	0.3
Injury severity		
Mild	205	56.3
Moderate	91	25.0
Severe	16	4.4
First degree	18	4.9
Second degree	4	1.1
Third degree	2	0.5
None reported	28	7.7

[a]ROTC, Reserve Officers' Training Corps.

Injury severity in the current study was most often classified as mild (56.3%) and did not result in restrictions to training or daily activities (36.5%). Early access to medical care has been previously associated with decreased time lost due to MSKI,[25] although the influence of AT medical care on measures of injury severity cannot be determined in the current study. Inconvenience in seeking medical care has been previously identified as a reason for not obtaining care in military trainees, particularly in women.[6] ATs in the current study provided embedded athletic training care, which facilitated convenient, early access to medical care. Future research should evaluate the impact of access to medical care on treatment-seeking behavior, time to medical evaluation, and time lost due to MSKI in ROTC populations.

Multiple interesting population characteristics emerged in the current study. Cadets who were in the Alpha ability group were found to have the highest frequency of MSKI. Alpha ability group refers to the members with the highest fitness within the ROTC battalion, often based on their 2-mile run time during the Army Physical Fitness Test. The increased MSKI frequency in this group contradicts previous findings that individuals with lower levels of aerobic endurance, as measured via a 2-mile run, are at increased risk for sprains and strains.[18] We suspect that members of the Alpha ability group in our study had a higher training volume than their peers, which has been found to increase overuse injury risk.[1]

MSKIs in the current study were most often reported by cadets in their third MS year (MS 3). The higher incidence of MSKIs reported during MS 3 may highlight a need to ensure recovery and return cadets to pre-MSKI performance levels at this critical time point in ROTC training. Cadets typically undergo Advance Camp training the summer after MS 3. Advance Camp is the pinnacle of ROTC training and contributes to a cadet's overall accession as an officer. Preparing for Advance Camp may be one reason that MS 3 cadets reported the most MSKIs. The desire to graduate from training on time and to avoid medical profiles that restrict training participation were the 2 most common reasons to avoid seeking medical care.[6] MSKIs that would prevent a cadet from attending Advance Camp would delay the cadet's progression in ROTC. Injuries that occur during MS 3 are not resolved are potentially detrimental to the cadet's future.

MSKIs in current study were also documented in ROTC cadre members. Cadre members, who are likely active duty or veterans, most likely have access to medical care through the army using the Tricare health care system. It is unknown whether they are using AT care in place of the Tricare system or whether this AT care is used to supplement Tricare medical care. The immediate and easy access to AT medical care likely played a role in cadre members' use of ATs. This use may also speak to the culture developed within the battalion. Negative perceptions associated with being injured have been reported as a barrier to seeking medical care.[6] If cadets know that the cadre uses the ATs for medical care, this may decrease the negative perception associated with seeking medical care.

Limitations of the current study include the use of ROTC programs with access to AT medical care. The embedded AT medical care in the ROTC programs evaluated likely influenced injury reporting. Injuries may have been reported due to the presence of embedded medical care in the current study population which would have otherwise gone unreported or not have been seen by a medical care provider. Informal information from our professional networks estimates that $<1\%$ of the 273 Army ROTC programs nationwide use ATs for medical care. A potential limitation was the loss of data due to nonreporting of injury if care was sought from other health care providers and went unreported to the AT. Other limitations include the noncollection of cadets' training programs and exposure data, because of its influence on overuse injury development. A methodological limitation was the use of fully deidentified data. EMR data without patient identifiers, including patient identification numbers, was compiled from a third party using a Safe Harbor Agreement. Thus, we were unable to report whether multiple injuries were attributed to a single patient. Finally, the current study was restricted to Army ROTC programs, and findings may not be transferrable to other branches of the military.

The current study provides the first description of MSKI across multiple ROTC programs, to our knowledge. Findings indicate that MSKIs sustained by Army ROTC participants are similar to those reported in both active duty and other entry-level training military populations. MSKIs were often insidious onset or noncontact mechanisms of injury. The vast majority of MSKIs could be directly attributed to ROTC participation. The knee was the most common anatomic location of injury. Population demographics indicate that those who sustain MSKI are often high achieving and at a critical time point in their ROTC career.

Future investigations are needed to expand the understanding of the impact of MSKI on cadets' ROTC progression as well as their future career as officers.

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