

Reconsidering Return-to-Play Times

A Broader Perspective on Concussion Recovery

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Background: Return-to-play protocols describe stepwise, graduated recoveries for safe return from concussion; however, studies that comprehensively track return-to-play time are expensive to administer and heavily sampled from elite male contact-sport athletes.

Purpose: To retrospectively assess probable recovery time for collegiate patients to return to play after concussion, especially for understudied populations, such as women and nonelite athletes.

Study Design: Cohort study; Level of evidence, 3.

Methods: Medical staff at a military academy logged a total of 512 concussion medical records over 38 months. Of these, 414 records included complete return-to-play protocols with return-to-play time, sex, athletic status, cause, and other data.

Results: Overall mean return to play was 29.4 days. Sex and athletic status both affected return-to-play time. Men showed significantly shorter return to play than women, taking 24.7 days (SEM, 1.5 days) versus 35.5 days (SEM, 2.7 days) ($P < .001$). Intercollegiate athletes also reported quicker return-to-play times than nonintercollegiate athletes: 25.4 days (SEM, 2.6 days) versus 34.7 days (SEM, 1.6 days) ($P = .002$). These variables did not significantly interact.

Conclusion: Mean recovery time across all groups (29.4 days) showed considerably longer return to play than the most commonly cited concussion recovery time window (7-10 days) for collegiate athletes. Understudied groups, such as women and nonelite athletes, demonstrated notably longer recovery times. The diversity of this sample population was associated with longer return-to-play times; it is unclear how other population-specific factors may have contributed. These inclusive return-to-play windows may indicate longer recovery times outside the population of elite athletes.

Keywords: concussion; return to play; elite athletes; sex differences

Concussions (also known as mild traumatic brain injuries) represent a serious public health concern, with between 1.8 and 3.6 million concussions occurring each year in the

United States (US) owing to sports- or recreation-related activities.²¹ The actual number of concussions suffered is likely much higher, as they are thought to be underreported.²² Athletes are reluctant to miss playing time, but premature return to sport can risk another concussion⁵ or increase risk of an orthopaedic injury.¹⁴ Given the potential for further harm from premature return from concussion injury and the concentration of research within the elite athlete population, an accurate perception of expected time for concussion recovery throughout the population could improve patient outcomes and reduce follow-on injury.

There is considerable variability among people suffering a concussion regarding symptoms, susceptibility, and recovery time. Once a concussion diagnosis is reached, the standard of care is that an athlete completes a return-to-play protocol to increase the likelihood of a safe return to sport. Based on past studies, this recovery is expected to occur within a 7- to 10-day window.^{1,23,25,26} Despite the frequent citing of this return-to-play window, there are reasons to consider that the typical concussion recovery time may be longer. The difficulty and cost of collecting concussion data adds sampling bias: most comprehensive data on return to play come from elite athletes. Elite athletes, typically defined as professional

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or intercollegiate athletes in the US,³³ have access to in-place medical and training staff, whose presence facilitates concussion data collection and expertise; however, the relative ease of collecting these data comes at a cost to the diversity of the sampled population.

For nonelite athletes, little is known about concussion recovery times. With respect to athletic competition levels, estimates of return-to-play time³³ are generally 5 to 7 days for professional athletes,³¹ 7 to 10 days for collegiate athletes,^{7,15} and approximately 30 days for high school athletes.^{6,8} Consistent tracking of nonelite athletes who sustain concussion is logistically difficult when compared with that of elite athletes. Consequently, most concussion studies of nonelite athletes use predetermined time frames for appointment intervals (eg, weekly).¹⁰ This likely leads to the appearance of longer recovery times for nonelite athletes, as appointment intervals are dictated by recovery time points. Elite athletes are typically seen much more frequently by a physician than a nonelite athlete is (multiple times weekly).

Most large studies of college concussion data involve National Collegiate Athletic Association (NCAA) collegiate athletes.^{7,15} Thus, concussion recovery estimates for the college-age population are primarily based on the most athletically elite 3.9% (all NCAA athletes) or 1.4% (Division I NCAA athletes) of college students.³⁰ Given the preponderance of elite athletes in this sample, concussion data could systematically differ from the general college-age population in important ways.

Putukian et al^{32,33} introduced the idea that perhaps elite athletes complete return-to-play protocols more quickly than typical athletes owing to fitness and medical access advantages. Some supporting evidence comes from the general trajectory of concussion recoveries: professional athletes recover more quickly than college athletes,³¹⁻³³ who in turn recover more quickly than high school athletes.^{2,33} At each progression in competitive level of sport, concussion recovery times are shorter; however, few non-elite athlete data have been available to test this difference systematically while accounting for other factors, such as age and incentives to return to play. Athletic achievement has physiologic and psychological components that are likely to change systematically at each level of athletic competition. Physical and psychological factors should be considered in assessing causes of return-to-play recovery time differences.

Another consequence of the focus on elite contact sports is sex imbalance. Men represent a large portion of the study literature, whereas women, like nonelite athletes, are less represented. Researchers have focused data collection on the activities most likely to produce a concussion^{19,20,38}: contact sports such as American football, ice hockey, and rugby, which are disproportionately played by male athletes.¹¹ Despite this bias, a growing body of research has focused on concussion among females. A number of measures have shown that women suffer stronger effects from concussions than do men in terms of susceptibility,¹¹ immediate postconcussion symptoms,⁹ postimpact neurocognitive testing performance,³ follow-up neuropsychological testing performance,¹⁰ and even 6-month postconcussion cognitive performance.¹⁷ Despite several studies showing this disparity in postconcussion recovery trajectory, other well-powered

studies have failed to find significant differences³⁶ and these data have even found the opposite effect in some measures.³⁴ Putative explanations for these sex-based differences include hormones, cervical strength, or self-report differences. Regardless, a more precise accounting of return-to-play recovery differences for women would improve understanding and expectations for the typical clinical recovery.

Based on prior studies of concussion symptom severity, susceptibility, and recovery trajectories,³⁷ our expectation was that underrepresented groups in the literature would show longer return-to-play times, while male elite athletes would confirm the expected 7- to 10-day window. The current retrospective database analysis is based on the unique military-academic athletic environment of the US Air Force Academy (USAFA) and aimed to describe probable return-to-play times for college-age concussion sufferers, including underrepresented groups such as women and nonelite athletes.

METHODS

USAFA cadet health clinic physicians and staff collected return-to-play medical data from September 2012 through November 2015. Details from all concussions for which cadets sought care in the clinic were entered into a database, which was de-identified for subsequent analysis. Recorded data included injury date, cause of injury, return-to-play date, intercollegiate athlete status, self-reported prior number of concussions, age, and sex.

The dependent measure in this study was days until return to play was completed, computed from injury date and return-to-play date. The USAFA return-to-play protocol was based on the 2012 Zurich consensus statement on concussion in sport (the statement has since been updated²⁴). To return to play, cadets must be symptom free after completing a 6-step return-to-play protocol and must also meet baseline measures in neurocognitive testing (ie, ImPACT testing) and other clinical assessments. After a concussion, intercollegiate cadets must be cleared by a clinic physician before they can return to play in their sport. Nonintercollegiate cadets are also cleared for return to play and return to military training by the same clinic physicians. This protocol was declared exempt by the USAFA Institutional Review Board and followed all ethical guidelines and US Air Force instructions and regulations.

Participants

The study comprised 512 concussions sustained by USAFA personnel who reported to the cadet clinic between September 2012 and November 2015. Of those 512 records, 414 (80.9%) contained completed return-to-play information. Incomplete documentation of return to play could have resulted for different reasons. A cadet could voluntarily stop returning for follow-up care, as in the civilian world. Any cadet whose concussion care was completed outside the cadet clinic would not be recorded within this database. Concussion causes were documented for all cases, indicating the specific cause and the activity category. Activity

categories included daily living events, contact sports, limited contact sports, noncontact sports, and military training. Daily living events included nonsport injuries, such as motor vehicle accidents or slips and falls.

Intercollegiate, or “elite,” athletes were operationally defined as cadets participating in a NCAA Division I sport. There are 27 intercollegiate teams at our institution. Each year, all cadets must pass the USAFA physical and aerobic fitness tests, which stipulate a high minimum standard of fitness even among non-intercollegiate athlete cadets (eg, “nonelite”).

Cadets receive free fully inclusive health care. The cadet clinic is open during extended business hours and weekends. For nonelite athletes, progression through the return-to-play stages is completed through physician supervision. Physicians educate these cadets on the return-to-play program and schedule weekly or more frequent follow-ups to supervise progress. In-season college athletes have access to certified athletic trainers on a daily basis; thus, injuries, including concussions, have more frequent evaluation with more frequent communication and visit coordination with physicians.

Study Design

A cohort study design was utilized to assess the full return-to-play time course of different subpopulations of cadets. The USAFA medical staff in the cadet clinic originally recorded the concussion data, as described earlier. The independent variables under consideration were sex and intercollegiate athlete status. The dependent variable was days until patient completed the return-to-play protocol. These groups were compared and considered in terms of historical averages in the literature.

RESULTS

Demographic Data

A total of 414 cadet medical records contained complete return-to-play protocol information. Within these 414 cases, 118 (28.5%) were female and 296 (71.5%) were male. The cadet student body is roughly 21% female. A total of 134 (32.4%) cases occurred among intercollegiate (elite) athletes, who represent 25% of the student body, while 280 (67.6%) were among nonintercollegiate (nonelite) athletes. Five officers included in this database were excluded from analyses for being outside the typical college age range. Four USAFA preparatory school students (all 19 years old) were treated at the same clinic and were included in the analyses. The mean age of all participants was 19.56 years (SD = 1.4; range, 17-24 years).

To best assess clinical differences in concussion return-to-play times among cadets, all participant data were analyzed with univariate analysis of variance (ANOVA) once extreme values were removed. The Tukey outlier method was used to detect unusually long return-to-play values and exclude them from analyses, treating any data point that was >75th percentile plus 3 times the interquartile distance as an outlier. The 25th-percentile data point (13 days) and the

TABLE 1
Days to Return to Play by Cause

Variable	n	Mean	SEM
Return to play ^a	399	29.389	1.250
Cause			
Contact	239	27.7	1.6
Limited contact	51	30.1	3.5
Military training	39	27.8	4.0
Other	54	35.4	3.4
Noncontact	14	35.4	6.7

^aMedian = 20, mode = 14, minimum = 5, maximum = 128.

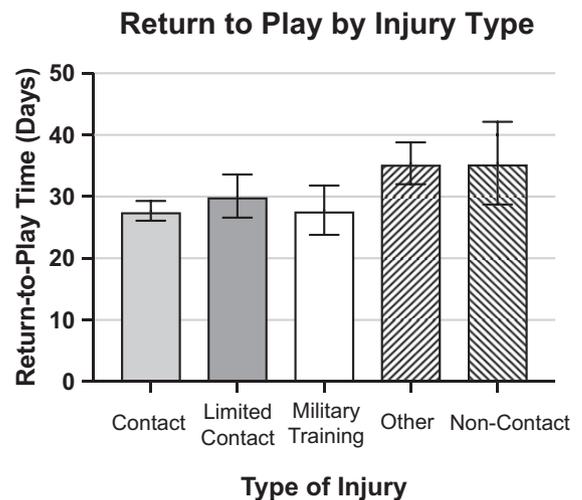


Figure 1. Mean ± SEM return-to-play time by cause category. No category was associated with significantly longer or shorter concussion return-to-play times.

75th-percentile data point (42 days) yielded a Tukey fence value of 129 days. Thirteen concussions in total, those lasting ≥129 days, were excluded from analyses. The remaining data were used for all subsequent analyses.

Cause of Injury Data

Concussion cause was analyzed with ANOVA, with days to complete return to play as the dependent measure; cause (military training, contact sports, limited contact sports, noncontact sports, or everyday living) was set as the between-participants factor in a single analysis. The analysis showed no significant effects of the concussion cause category on length of recovery ($F_{4,396} = 1.304, P = .268$). Table 1 and Figure 1 show data for return-to-play time by cause.

Concussion Return-to-Play Data

Concussion recovery was then analyzed with ANOVA, with days to complete return to play as the dependent measure (Table 2); sex (male, female) and athletic status (intercollegiate athlete, nonintercollegiate athlete) were

TABLE 2
Days to Return to Play by Demographics

Variable	n	Mean	SEM
Return to play ^a	399	29.38	1.250
Sex: status			
Female			
Nonelite	87	40.7	2.6
Elite	27	30.2	4.6
Male			
Nonelite	181	28.9	1.8
Elite	104	20.5	2.4

^aMedian = 20, mode = 14, minimum = 5, maximum = 128.

Return to Play by Sex and Athlete Type

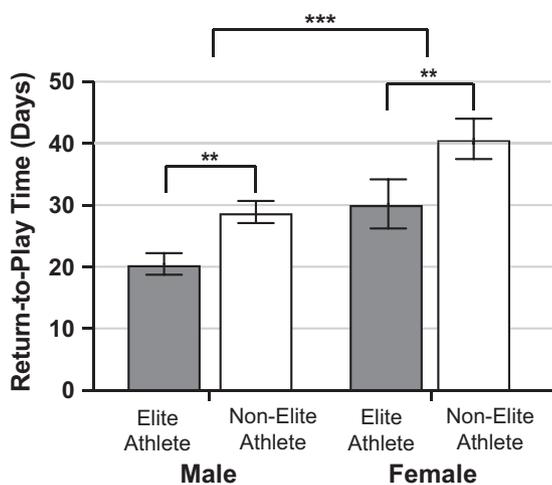


Figure 2. Mean \pm SEM return-to-play time by sex and elite athlete status per 2×2 analysis of variance. Both main effects were statistically significant and did not interact. $**P < .005$. $***P < .001$.

set as the between-participants factors in a single analysis. The omnibus ANOVA showed each variable to have a significant main effect, with no significant interactions (Figure 2).

The main effect of athletic status was significant ($F_{1,395} = 9.741, P = .002$): elite athletes completed return to play faster (mean = 25.35 days, SEM = 2.6) than nonelite athletes (mean = 34.7 days, SEM = 1.6). The main effect of sex was also significant ($F_{1,395} = 12.622, P < .001$), showing that male cadets (mean = 24.7 days, SEM = 1.5) returned to play faster than female cadets (mean = 35.5 days, SEM = 2.7). Age had no significant effect on return-to-play time ($F_{7,387} = 1.113, P = .35$).

Prior concussion history was available for a limited number of participants ($n = 239$), who were clustered for analysis into 3 groups: no prior concussions ($n = 186$), 1 prior concussion ($n = 34$), and ≥ 2 prior concussions ($n = 19$). Prior concussion history showed significant effects on return-to-play time ($F_{2,227} = 7.509, P < .001$) and no interactions; the main effects of sex ($F_{1,227} = 8.186, P = .005$) and

Return to Play by Number of Concussions

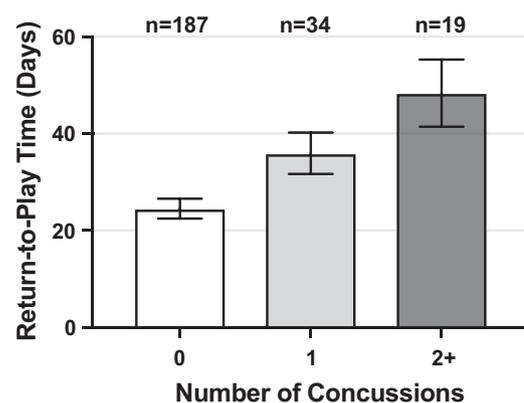


Figure 3. Mean \pm SEM return-to-play time by prior concussion history ($n = 240$). Data showed a significant main effect of prior concussions, which did not interact with the significant main effects of athlete status and sex.

athletic status ($F_{1,227} = 7.149, P = .008$) remained statistically significant within this subset even with the additional parameter of concussion history. Concussion history data showed that ≥ 2 concussions required the longest recovery (mean = 48.4 days, SEM = 6.92), followed by 1 prior concussion (mean = 35.9 days, SEM = 4.26) and no previous concussion (mean = 24.52 days, SEM = 2.05) (Figure 3).

Confirmatory Survival Analyses

Owing to the temporal nature of concussion recovery data, there can be concern about analysis with methods designed for normal distributions even with proper outlier removal. As such, we performed confirmatory survival analyses—a nonparametric test used to compare durations of events between 2 groups in epidemiologic settings—to validate the differences demonstrated in both main effects. Both survival analyses confirmed initial findings. Male cadets returned to play significantly faster than female cadets ($\chi^2 = 17.89, df = 1, 398, P < .0001$), and elite athletes returned to play more quickly than nonelite athletes ($\chi^2 = 19.45, df = 1, 398, P < .0001$) (Figures 4 and 5).

DISCUSSION

Return-to-play concussion data from the USAFA show a mean recovery time of 29.4 days, significantly longer than the 7- to 10-day window most commonly reported in the concussion literature.^{23,25,26,33} This shorter 7- to 10-day recovery time window is calculated from data collected predominantly from male elite athletes playing contact sports. The USAFA data set's diversity and large sample size show longer return-to-play times in this college-age population, particularly outside of elite athletics; however, as with elite athletes, because of the unique nature of a military service academy student body, it is unknown if the results can be generalized to all college-age patients.

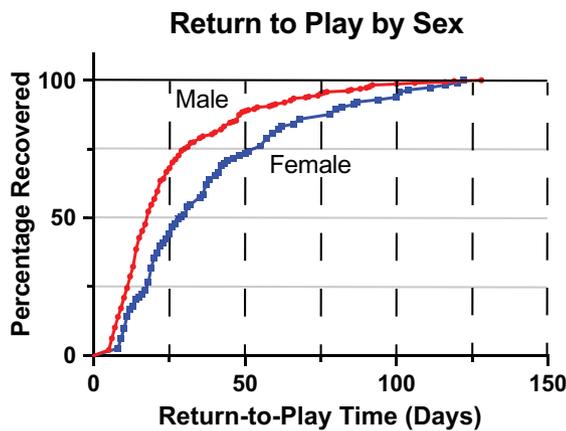


Figure 4. A survival analysis with recovery to baseline plotted upward. Men (red) returned to play significantly more quickly than women (blue).

The average concussion return-to-play time was notably longer in this study than prior estimates of concussion recovery for all groups, but some subpopulations hewed more closely to recovery findings in prior studies. One immediately apparent difference in the currently analyzed population is its diversity when compared with many concussion studies: women and nonelite athletes are well represented in this sample. Could these population inclusions alone tilt mean recovery times toward longer figures? This does not appear to be the case. If the return-to-play analysis is restricted to only the subpopulation that best matches previous concussion studies (male intercollegiate athletes), the USAFA mean return-to-play time, at 20.47 days, still remains longer than the prior window. Despite the longer return-to-play time shown by USAFA male athletes when compared with historical norms, male intercollegiate athletes were the demographic subgroup that showed the quickest return to play in the USAFA sample.

Greater sampling diversity is associated with mean return-to-play recovery times. Other subpopulations of interest (including women and nonelite athletes) demonstrated longer recovery toward full return to play. Female cadets returned to play approximately 35.5 days after a concussion, while male cadets had a mean return of 24.7 days after initial concussion—a mean of 11 days longer for women. Prior work showed that female athletes suffer concussions of greater severity or a slower recovery trajectory^{10,11}; our data support this by showing a slower overall recovery. Our data do not allow speculation regarding the cause of these sex-based recovery differences, but it seems generally more consistent with physical explanations, such as cervical strength or biomechanical explanations.

Nonelite athletes are lightly represented in the concussion literature, but in our study, this group too showed considerably longer return-to-play times when compared with intercollegiate athletes: 34.7 days for nonelite athletes versus only 25.4 for elite athletes. The enhanced fitness, greater incentive to return, or greater access to care of elite

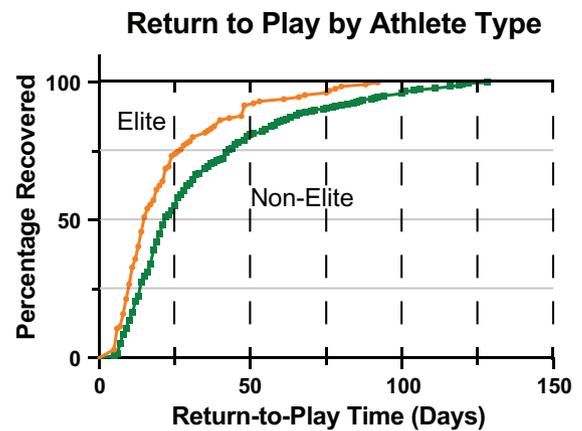


Figure 5. A survival analysis with recovery to baseline plotted upward. Elite athletes (yellow) returned to play significantly more quickly than nonelite athletes (green).

athletes could explain why nonelite athletes take longer to recover from concussions. However, all cadets have physical fitness requirements, so other explanations, such as access to care and incentives to return, may be more pertinent. Given a long history of concussion symptom nondisclosure among elite athletes,^{16,18,35} a bias in symptom self-reporting seems a more likely explanation for recovery time disparities in this population than do physical differences.

The USAFA's unique environment may improve return-to-play data collection accuracy when compared with civilian schools. All cadets have free on-site walk-in access to concussion care, with a mean medical clinic visit rate of 4.6 times per concussion. Class attendance is mandatory unless a cadet has a medical waiver, which (with a military culture of compliance) could encourage more follow-up care visits than in a civilian population. In addition, intercollegiate athlete cadets have daily access to team athletic trainers and physical therapists, similar to other NCAA Division I athletes. Ultimately, this data collection environment includes a high level of care and accountability for all cadets with concussion, whereas most environments support only elite athlete postconcussion care to this degree. Fewer barriers to treatment can demonstrate a more complete picture of concussion injuries and enhanced temporal precision in recovery. In most civilian collegiate settings, cost of care and the inconvenience of frequent follow-ups would limit treatment frequency relative to that at a military institution such as the USAFA.

Despite better accuracy in data collection, it is unclear how a military academy environment could affect actual concussion recovery times—some aspects could improve recovery while others may hamper it. On the positive side, greater access to free, inclusive health care could facilitate more rapid recovery. In terms of providing more timely care and declaring a cadet healthy, the medical care at the USAFA could shorten return-to-play times. Cadets' generally high levels of physical fitness may decrease recovery time,^{4,27} too, as personal fitness has been correlated with concussion recovery¹² and symptom levels.²⁸ The military

command structure may also encourage cadets to have greater compliance with health care professionals, as clinic physicians are higher-ranking military officers than cadets. Finally, USAFA admission is difficult to gain, and cadets are high achievers; given the difficulty of making up missed work, cadets are typically motivated to not fall behind by unnecessarily delaying full return to play.

Other aspects of military academy life are likely to hamper concussion recovery. First, the academic intensity of the USAFA could make concussion recovery more difficult. The average cadet course load includes 6 classes per semester, military responsibilities, and mandatory physical fitness activities. Extreme time demands could entice cadets to begin academic work before they have sufficiently recovered, which could reactivate symptoms and lengthen recovery time.¹³ Cadets themselves have special characteristics, which may systemically affect recovery time. Their care in compliance with doctor's instructions, while laudable, could lengthen recovery time. Lingering concussion symptoms, while unwanted in any patient, could affect a cadet's future ability to fly or be commissioned, particularly if untreated; this gives cadets an incentive to take recovery quite seriously.

Given the differences in population and environment, it is worth considering what the data can tell us about concussion recovery times, particularly between elite and non-elite athletes. Prior work has suggested that access to care, clinician concussion familiarity, fitness, and motivational differences generally explain the difference in concussion return-to-play time between elite and nonelite athletes.³³ In the cadet population, some of these factors are less pertinent than others. While NCAA Division I athletes maintain elite fitness, all cadets are fit, so fitness level seems unlikely to be driving the elite athlete return-to-play differences here. Similarly, clinician familiarity with concussion treatment is unlikely to be a factor; USAFA physicians diagnose and treat 200 to 250 concussions per year and are familiar with current standards for concussion care. There are considerable access-to-care differences between elite and nonelite athletes. Nonathlete cadets must visit the cadet clinic, but athletes have nearly daily access to certified athletic trainers; this hampers easy comparison of return-to-play time. Despite this difference in frequency of treatment, access to postconcussion care for cadets would likely be more similar between intercollegiate athletes and nonintercollegiate cadets than in the general population, where nonathletes visiting a doctor would require a prior appointment and a copay. Motivation for quick recovery is another factor cited in elite versus non-elite athlete return-to-play differences. While nonathletes may always have less motivation to return to play than elite athletes, cadets may exaggerate this difference given their motivation to recover properly to maintain brain health for pilot qualification. An unresolved concussion could jeopardize a cadet's future ability to become an air force officer or qualify as a pilot.

Some limitations for the current study include unique aspects of the environment, the population, and even the location. Academy cadets are likely to be well above the population average in terms of fitness and academic

performance, limiting generalizability to the average college-age person or recreational athlete. Roughly 20% of follow-up data were not available, which has the potential to alter the concussion statistics. Elite athletes had more frequent access to care, while nonelite athletes were more self-directed in their return-to-play efforts. Finally, even the high altitude of the USAFA (officially 7258 ft above sea level) has been shown to have potentially protective effects on concussion recovery that are different from sea level.²⁹

In closing, the current study of concussion injury at a military service academy shows a return-to-play time for concussions that is longer than that presently considered typical. For women and nonintercollegiate cadets, return-to-play times were longer still. The longer concussion recovery times seen in these data may reflect some unique characteristics of a military-academic environment or the cadet population, but they may also reflect the wider concussion-injured population beyond elite athletes playing contact sports. After all, the intense demands of intercollegiate sports may be a strong incentive to return from concussion that a typical college-age concussion sufferer is not likely to sense. Future work should continue to assess more diverse populations alongside elite athletes for a better understanding of the full spectrum of concussion recovery trajectories, which can be generalized more easily to the public at large.

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