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Part II: Risk Factors for Stress Fractures in Female Military Recruits

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ABSTRACT
Introduction:
Stress fractures (SFx) represent a significant proportion of injuries in military recruits internationally. Stress fractures disproportionately affect female recruits, a disparity that has similarly been consistently demonstrated in female athletes. Stress fractures result in medical morbidity, financial burden, and medical discharge from military service. This review presents current literature regarding SFx risk factors to identify and/or mitigate in this high-risk population.

Methods:
A literature review was conducted using PubMed to find relevant articles. We utilized keywords stress fracture, military, recruits, female, risk factors, modifiable, non-modifiable, overuse, nutrition, and/or prevention. Articles older than 10 years (published before 2010) were not considered. Review articles were considered, but if a research article was cited by a review, the research was included directly. Articles with primary military data, members of the military as subjects, especially when female recruits were included, were strongly considered for inclusion in this review.

Results:
Modifiable risk factors for SFx include nutritional deficiency, especially of iron, vitamin D, and possibly calcium, poor physical fitness, suboptimal training programming for injury development and recovery, load carriage, and military footwear. Non-modifiable risk factors include female sex, greater height, lower weight and body mass index in females but lower or higher weight and body mass index in males, lower body fat percentage, and lower bone mineral density. In addition, menstrual dysfunction, low energy availability, later age at menarche, and iron deficiency pose unique risks to female recruits. Preventive measures include leadership education, programs with recovery considerations, and risk factor screening.

Conclusion:
This review, Part II of a two-part series, guides multidisciplinary management of military recruits, especially females, who are at risk for developing SFx. Unique nuances of the military recruit require specific knowledge to reduce high incidence rates of injury internationally.

CATEGORIZING RISK FACTORS

Stress fracture (SFx) risk factors can be categorized as modifiable or non-modifiable[1,2] (Table I). Modifiable risk factors include nutritional deficiency, fitness, training program design, and equipment. Non-modifiable risk factors include anthropometric factors, patient sex, and bone strength components. Identifying modifiable factors provides an opportunity to make program changes and mitigate injury risk. Recognition of non-modifiable risk factors can prompt emphasis on prevention in certain recruits. In this review, risk factors are categorized as non-modifiable if they are unlikely to significantly change just before or during training (Tables II and III).

SFX RISK FACTORS SPECIFIC TO THE FEMALE RECRUIT

Risk factors specifically affecting female recruits include the female athlete triad (menstrual irregularity, low energy availability, and decreased bone mineral density [BMD]) and later age at menarche.[3–6] Although iron deficiency is a risk factor for SFx in men and women, women are impacted more substantially.

The Female Athlete Triad

The female athlete triad is associated with SFx risk[4–6]; it is well described in athletes[7] but understudied in military populations.[3] In 136 female United States Military Academy (USMA) cadets, menstrual dysfunction was highly prevalent during the first 3 months of training but not associated with SFx.[8] The authors of this study acknowledged dissonance from athlete studies, emphasizing likely underpowered results and a lack of subjects with complete amenorrhea.[4] Additionally, this self-reported data may be underreported in military recruits. It seems that associations demonstrated in athletes

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TABLE I. Overview of Risk Factors for SFx Development in Military Recruits

Modifiable risk factors	Non-modifiable risk factors	Female-specific risk factors
Nutritional deficiency: iron, vitamin D, possibly calcium	Female sex	Menstrual dysfunction
Poor physical fitness	Greater height	Low energy availability
Suboptimal training program (lack of gradual progression, inadequate recovery, non-adherence to predefined program, high running duration and frequency, long marching distances)	Lower weight and BMI in females, lower or higher weight and BMI in males	Iron deficiency
Load carriage during walking, marching, or running during training	Lower body fat percentage	Later age at menarche
Military footwear (combat boots)	Lower bone mineral density	

TABLE II. Modifiable Risk Factors for SFx Development in Military Recruits

Risk factor	Specific parameter or outcome associated with SFx risk
Nutritional deficiency	• Poor vitamin D and calcium intake[1,6,13] • Low serum vitamin D level (25OHD)[12] • Iron deficiency[11]
Poor fitness	• Exercising twice per week or less[17] • Not exercising in the year before training[19] • U.S. Army Step Test failure[22] • Slower run times[23,24] • Fewer sit-ups and push-ups able to be performed in Air Force fitness testing[24]
Training program (modes, intensity, frequency, duration)	Protective factors determined to result in decreased SFx rates: • Systematic run progressions, grouping recruits by ability, running for time instead of distance, emphasizing adequate recovery between sessions[26] • Reduced running duration and frequency[31] • Individualized programming, training relevant to required military skills[27] • Leadership adherence to predetermined training protocol, reduced cumulative marching distance, flatter training terrains[28]
Load carriage	Detrimental biomechanical effects associated with SFx: • Increased stance time, ground reaction forces, joint reaction forces, cumulative bone stress, increased hip flexion, decreased ankle dorsiflexion and plantarflexion[31] • Increased stride frequency, rearfoot eversion, vertical loading rates, peak absolute free moment[32]
Military footwear	Assault/combat boots (compared to training shoes) are detrimental for: • Peak vertical impact values[35] • Higher peak plantar pressure, impulse and loading rates at 3rd metatarsal head, smaller and earlier peak ankle dorsiflexion, later heel-off, greater peak plantarflexion moment and ankle joint stiffness[36]

can be demonstrated in recruits with adequate sample sizes. A study of 2,962 female U.S. Marine recruits found that amenorrhea in the year before matriculation predicted SFx.[4] In female U.S. Army recruits, oligomenorrhea (fewer than 10 menstrual cycles in the prior year) was associated with lower spine and hip BMD.[6]

The goal of training, to turn civilians into fit soldiers, may contribute to low energy availability.[5] In U.S. Navy recruits, negative energy balance (marked by significantly above average weight loss) was associated with SFx.[6] A strict meal schedule was thought to contribute to poor recovery. Recruits were limited to eating during mealtimes and for a limited time period. In female recruits, restrictions may contribute to female athlete triad development and to greater injury risk.[5,6]

Low energy availability can result from increased exercise intensity, load carriage, or inadequate caloric repletion.[5,6] It can also be intentional by recruits with fitness goals or in programs, such as U.S. Ranger training, with deliberate restrictions.[5] In 2001, McNulty characterized the epidemiology of disordered eating in 1,278 female military personnel using questionnaire data from U.S. Army, Navy, Air Force, and Marine medical centers.[9] This study demonstrated a prevalence of 1.1% women in the military with anorexia nervosa, 8.1% with bulimia nervosa, and 62.8% with an unspecified eating disorder.[9] There were significantly higher rates in the Marines: 4.9% with anorexia nervosa, 15.9% with bulimia nervosa, and 76.7% with an unspecified eating disorder. Women in the Marines demonstrated the highest rates of amenorrhea (22.3%) when compared to other branches

TABLE III. Non-modifiable Risk Factors for SFx Development in Military Recruits

Risk factor	Specific parameter or outcome associated with SFx risk
Greater height	• 2.4% average height difference between female recruit SFx cases and uninjured controls[2,11,38] • 180 cm or taller height in male and female recruits[37]
Weight (low in females, low or high in males)	• Lower body weight in males and females; less than 78 kg in females[37] • Higher body weight in male recruits[37]
BMI (low in females, low or high in males)	• Underweight BMI in males and females[29,37] • Obese BMI in males[30,37]
Lower body fat percentage	• Lowest decile for body fat percentage compared to highest decile in cohort[39] • Lower body fat percentage[21]
Bone mineral density and bone mineral content	• Lower BMD at the lumbar spine, femoral neck, and whole body[3,12] • Lower BMD at the total hip[3]
Menstrual irregularities	• Amenorrhea in the year before matriculation[4] • Oligomenorrhea (fewer than 10 menstrual cycles in the year prior) associated with lower spine and hip BMD[6]

(7.4% in the Air Force, 9.9% in the Navy, and 10.2% in the Army).[9] Disordered eating behaviors increased during the semiannual measurement periods, and women reported negative career outcomes in the Army and Marines after failing a measurement evaluation.[9] Menstrual disturbances secondary to energy deficiency can decrease BMD and increase SFx risk.[5,6]

Age at Menarche

Later age at menarche has also been associated with SFx and is related to the protective effects of estrogen for BMD. Research in military populations on age of menarche is limited. A study of female USMA Army recruits found that those with later age at menarche were more likely to sustain SFx (13.1 years for cases, 12.1 years for controls, $P < .01$).[3]

Iron Deficiency

Although iron deficiency can occur in male and female recruits, there is an increased prevalence in women.[2,10] Menstruation and lower iron intake likely contribute to this discrepancy.[10] A study of U.S. female army personnel demonstrated that 32.8% had iron deficiency immediately following training.[10] 13.4% of women were deficient just before training, and 9.6% were deficient following 6 months of permanent assignment after training.[10]

In Yanovich et al.'s study of Israeli Defense Forces (IDF) recruits, 18-19% of female recruits were anemic at the onset of training, compared to 7.7% of males.[2] At this time point, 50.9-61.4% of female recruits were iron deficient, compared to 10.2% of males. This study also found an association between anemia and decreased maximal oxygen consumption (VO_2 max), significant in female recruits.[2] SFx was also associated with anemia, iron deficiency, and lower transferrin saturation.[2]

Moran et al. corroborated the association between SFx and iron deficiency in female IDF recruits.[11] They concluded that SFx was associated with being taller, leaner, iron deficient, and more strongly endorsing subjective "burnout" using a 1-7 scale questionnaire. They associated iron deficiency with depression, fatigue, and burnout and proposed iron deficiency as a primary etiology for these issues.[11]

MODIFIABLE RISK FACTORS

Vitamin D and Calcium

Low vitamin D is a demonstrated SFx risk factor, and vitamin D with calcium has demonstrated protection.[6,12] A review of 11 studies associated lower vitamin D and calcium intake with SFx risk in female recruits.[6] Two Finnish studies in this review demonstrated lower serum 25-hydroxy-vitamin D (25OHD) and higher parathyroid hormone (PTH) in cases than controls.[6] Higher PTH commonly results from low vitamin D and reduces BMD and bone mineral content.[6]

In a 2019 Marine Corps study, recruits received placebo or fortified snack bars with calcium and vitamin D during training.[1] Supplementation reduced bone turnover markers (bone alkaline phosphatase or BAP, and tartrate-resistance acid phosphatase or TRAPb) and prevented a serum 25OHD decline seen in prior recruits. Body weight (BW) and body mass index (BMI) decreased during training in the placebo group but did not change with supplementation. Body fat percentage decreased in both groups, but to a greater extent with placebo.[1] A U.S. Navy study with the same design found that supplementation reduced SFx incidence in female recruits by 20%.[13] Further investigation is needed to isolate calcium's effects without vitamin D.

Several studies have investigated vitamin D without calcium. In 2015, Davey et al. investigated vitamin D levels in male Royal Marine recruits at training weeks 1, 15, and 32.[12] They found a baseline 25OHD level less than 50 nmol/L to be associated with SFx. At week 32, 25OHD was lower in SFx cases than controls. 25OHD decreased in all recruits during the second half of training.[12] In a unique population training for months, this may indicate inadequate vitamin D repletion, with effects compounding over time. Andersen et al.'s study of female U.S. Army recruits similarly demonstrated that after an 8-week program, average 25OHD decreased from 72.9 to 63.4.[14] These results were unexpected in the summer in the Southeastern USA and further support that dietary intake is inadequate for recruits.

Lutz et al. more directly confirmed that dietary intake of vitamin D and calcium was below recommended levels in female U.S. Army recruits (15 μg/day and 1,000 mg/day).[15] Before training, the mean intake of vitamin D was 3.9 μg/day and 887 mg/day. During training, the means were 4.1 μg/day and 882 mg/day. Recruits remained deficient during a period of increased nutritional requirements. Further, bone turnover biomarkers and PTH increased significantly during training.[15]

Fitness

Studies support adequate fitness as protective against SFx in recruits. However, a 2008 review of fitness trends in the U.S. military found that recruits' fitness declined from 1993 to 2006.[16] The prevalence of overweight recruits increased from 22.8% to 27.1%, and obesity prevalence increased from 2.8% to 6.8%.

A 2019 study of Finnish recruits examined physical activity and SFx and found that those who exercised more than twice per week sustained significantly fewer SFx.[17] A study of the U.S. Military, U.S. Naval, and U.S. Air Force Academies found that 66.9% of recruits played three or more high school sports, which was associated with fewer lower extremity (LE) injuries in training. These recruits may have received protection by not being specialized in a single sport.[18] Interestingly, female recruits who attended a pre-training preparatory academy were at increased risk for LE injury.[8] These recruits may have felt unprepared for training, and poor fitness level may be confounding. Pretraining programs also may effectively increase training duration and injury risk. In female IDF recruits, those who exercised in the year before training demonstrated a 9.6% SFx incidence, compared to 12.8% in those who did not.[19] A 3-year IDF study demonstrated that female recruits who withdrew had lower quadriceps strength and slower running times than those who completed training.[20]

A 2016 U.S. Army study of female recruits investigated the step test, which involves repeatedly stepping onto and off of a 12-inch-high platform at a set cadence for 5 minutes.[21] Recruits need to qualify by body fat percentage or by passing the step test. Stress fracture risk was higher among weight-qualified but "unfit" women (who did not pass the step test). Among "fit" women, there was no significant risk difference between weight-qualified and weight-disqualified. Unfit women utilized healthcare more for injury, even if they were weight-qualified.[21] These findings corroborate SFx risk with poor fitness even when considering body composition independently. Another study of female U.S. Army recruits similarly demonstrated the association between step test failure and SFx or other musculoskeletal injury (MSI).[22] Those who failed had 76% higher SFx incidence and 35% higher risk of other MSI. One-third of weight-qualified female Army recruits fail fitness testing.[21]

A review of 11 military studies concluded that lower aerobic capacity and smaller muscle may contribute to female recruits' increased SFx risk.[6] One study divided female U.S. Marine recruits into quartiles based on 1.5-mile run times; the slowest quartile demonstrated a 3-fold higher SFx risk compared to the fastest quartile.[6] A similarly designed Army recruit study also found over 3 times greater injury risk for the slowest quintile times compared to the fastest.[23] Another U.S. Army study comparing male and female recruits found that injury rate declined with faster running times in general.[6] The fastest female Army recruits had similar mile times and injury rates as the slowest male recruits.

An Air Force study found that slower run times significantly increased femoral SFx risk in male and female recruits.[24] Other methods of fitness testing also demonstrated predictive value—the ability to perform more sit-ups and push-ups reduced SFx risk in female recruits.[24]

Training Intensity

Different militaries have demonstrated risk reduction by training program modification. In 2019, a cohort of U.S. female Army recruits demonstrated improved bone strength parameters during training (total volumetric BMD, trabecular volumetric BMD, and trabecular thickness) ($P < .05$).[25] The authors interpreted that increased SFx incidence during training is thus likely due to an imbalance between bone adaptation and additional loading. Recruits are at risk for SFx despite these adaptations.

A study of U.S. Army, Navy, Air Force, Marine Corps, and Coast Guard data from 2003 to 2012 demonstrated that SFx incidence peaked in recruits in 2005 and in all active members in 2008.[26] During 2003 to 2008, wartime recruitment increased the number of less fit recruits, with more intense training to accommodate more rapid deployments. Prevention measures in response to the increased injury incidence contributed to decreased fracture rates from 2008 to 2012.[26] These included leadership education, discouraging use of physical activity as punishment, and adjusting training schedules to avoid overtraining. These authors specifically recommended systematic run progressions, grouping individuals by ability, running for time instead of distance, and emphasizing adequate recovery between sessions.[26]

A recent 10-year study of male and female IDF recruits demonstrated up to 20% SFx incidence initially in all recruits, highly detrimental to units' capabilities.[27] Program adjustments were made to individualize activities and to improve relevance to combat skills. By the end of the study, the yearly average SFx incidence was 5%.[27]

A review of nine IDF studies from 1983 to 2015 analyzed implementations that likely contributed to decreased SFx incidence.[28] In 1983, the IDF reported an incidence of 31% on an infantry training base, leading to training modifications. Simply adhering to a predetermined protocol was associated with decreased SFx incidence. This change was made to prevent commanders' "considerable additions" to training programming. Reducing cumulative marching distance and training on flatter terrains were also associated with decreased SFx incidence.[28]

Overall, it is recommended to gradually increase exercise intensity with a structured program.[4,5,29] A recent study of recruits in India demonstrated a large disparity in SFx incidence between male and female recruits (6.9% vs. 15.8%); the authors suggested separate training between male and female recruits initially to allow female recruits to progress appropriately.[4] They also recommended periodization of training with a week of rest near weeks 3-4. In this cohort, the maximum fracture incidence occurred during week 4 for males and during week 9 for females.[4]

Load Carriage and Equipment

Military training includes load carriage, and recent studies have found associated risks. Risk is more substantial for female recruits, who often use equipment designed for men and carry the same weight as male recruits rather than BW-proportionate loads.[30]

A biomechanics study of female runners investigated applying variable loads while walking or running.[31] Carrying a 10%, 20%, or 30% of BW load increased stance time, when feet are on the ground with load applied. Carriage also increased ground reaction forces, joint reaction forces, and cumulative bone stress, especially at the tibia. The cumulative stress of a 2-hour march load carriage was comparable to an unweighted 45-minute run. During daily U.S. Army training, recruits on average run 36 minutes and march with 45% BW load carriage for 129 minutes. When writing training programs, time spent walking with load carriage should be considered in addition to running duration.[31]

A similar study of female treadmill runners aged 18-20 years compared loaded and unloaded treadmill running trials using 4.5-, 11.3-, and 22.7-kg loads.[32] These equated to about 7.5% BW, 19% BW, and 38% BW. Loading at 11.3 kg and heavier increased average vertical loading rates and peak absolute free moment, both associated with tibial SFx.[32] Requiring the same disproportionate load carriage for women as men should be reconsidered if unnecessary.

Studies have also investigated equipment effects. An IDF study compared SFx risk in female recruits wearing a standard vest to wearing a vest designed for them.[33] They reported satisfaction with improvements, but the authors concluded that vest design did not decrease SFx risk and that weight reduction is likely more important. However, the new vest design was associated with a similar SFx incidence to the old design, despite the new vest being over 40% heavier. The new vest was also associated with a decreased incidence of long bone SFx, possibly related to a superior design that modified weight and/or force distribution.[33]

Constantini et al. also examined equipment modification for 213 IDF female recruits.[34] Modified rifles and vests with a 25% weight reduction demonstrated a SFx rate of 8%, compared to a control rate of 18.3% with original equipment. Stress fracture distribution was unchanged, reassuring against overloading different SFx sites after equipment modifications.[34]

Footwear can also affect SFx risk.[35,36] Carden et al. studied the effects of "foot drill" in the British Army, when recruits march and are encouraged to loudly stamp the heel.[35] They found that this activity generates higher forces, loading rates, and accelerations than running or load carriage.[35] Peak vertical impact values during foot drill were higher than those in university students wearing training shoes to practice foot drill.[35] Students' athletic shoes possibly dissipated forces superiorly to recruits' Combat Assault Boots.[35] Nunns et al. similarly found several biomechanical differences for male Royal Marine recruits' assault boots compared to training shoes.[36] Boots demonstrated higher peak plantar pressure, higher impulse and loading rates at the 3rd metatarsal head, smaller and earlier peak ankle dorsiflexion, later heel-off, and greater peak plantarflexion moment and ankle joint stiffness, all of which are risk factors for 3rd metatarsal SFx.[36] Future studies should clarify benefits of training in boots, especially if environmental protection is not needed.

NON-MODIFIABLE RISK FACTORS

Anthropometric Data

In general, female recruits are shorter, lighter, and have higher body fat percentages than males, and these differences are important for understanding disproportionate SFx risk.[20,24]

Height

Studies demonstrate increased SFx risk in taller recruits, possibly related to longer LE bones with increased bending stress.[6,37] Three recent studies have found greater risk in taller female IDF recruits,[2,11,38] with a 2.4% average height difference between SFx cases and uninjured controls. Discordant with these findings, Knapik et al. found that Army female recruits 180 cm or taller were at little elevated risk, with an odds ratio of 1.07.[37]

Weight

Weight may be a poor SFx predictor, as it does not always correlate with body composition or fitness. Studies indicate lower weight as a risk factor for women and a potentially bimodal risk association for men.

Knapik et al. also found an association between lower weight and SFx in male and female U.S. Army recruits.[37] Female recruits over 78 kg also demonstrated risk protection compared to those in the Army's normal reference weight range. Heavier men demonstrated increased risk, a bimodal association of risk in higher and lower weight extremes that did not exist for female recruits. Lower BW can be contributed to by lower bone mass, lower fat mass, and/or lower lean mass or muscle mass.[37] Lower lean mass or muscle mass may worsen muscular fatigue, which especially applies to female recruits. Consideration of the tall, lean female recruit susceptible to the female athlete triad is important. Lower weight and decreased fat mass also contribute to decreased chronic bone loading.[6] Muscle forces produce the greatest loads on bone, and decreased lean mass can reduce beneficial BMD adaptations. These hypotheses may explain the protective effect seen in heavier women in this study.

Body Mass Index

Lower BMI has also been associated with increased SFx risk. Similar to the influence of weight on SFx development, there is support for bimodal BMI risk.[30,37] Finestone et al.'s 3-year prospective study of IDF recruits in 2014 found significant SFx risk with low BMI in male and female recruits, although this result was insignificant with multivariate analysis.[20] Variables considered were age, height, quadriceps force, VO2 max, and weight, fat mass, lean mass, and fat percentage at induction and at week 14 as well as their changes.[20] The loss of significance may represent the inability for BMI to differentiate body composition. It may also represent decreased precision from combined male and female data—in 2012, Strohbach et al.'s study of only female IDF recruits found significant SFx risk with lower BMI.[38]

A 7-year study of U.S. Armed Forces recruits found a strong correlation between tibia or fibula SFx incidence and underweight BMI.[29] Interestingly, members of the military who were no longer recruits demonstrated increased risk for these SFx with obese BMI. Obese non-recruits may be susceptible to developing SFx due to poor fitness.

Low BMI was corroborated as a risk factor in the U.S. Army in both male and female recruits.[37] Use of an electronic database provided significantly greater power for this study (475,474 men and 107,906 women). Again, male recruits demonstrated bimodal BMI risk, and female recruits demonstrated increased risk with lower BMI and protection with higher BMI.[37] A U.S. Army study similarly demonstrated increased risk for obese male recruits but not obese female recruits.[30] Higher BMI may provide protection for women from low energy availability or from BMD losses; however, this effect may not be observed in men because of the more significant influences of poor fitness, earlier fatigue, and/or significantly higher acute bone stress with the initiation of training.

Body Composition

There has been limited study regarding body composition, likely related to limited data acquisition at the start of training. A U.S. Army study of male and female recruits found that in the lowest decile for body fat percentage (assessed by dual energy X-ray absorptiometry) demonstrated a 20-27% greater SFx risk than those in the highest decile.[39] Finestone et al. also found lower body fat to be a risk factor in female IDF recruits.[20]

In 2016, Krauss et al. studied female U.S. Army recruits during the first 6 months of service.[21] They found an increased SFx risk with lower body fat; however, those with higher body fat sustained more other MSI and utilized healthcare more frequently. This may illustrate the protection provided by chronic bone loading with heavier weight, but that heavier loads can predispose recruits to injuries related to intense exercise.

Bone Mineral Density

Low BMD is frequently associated with SFx in athletic populations,[7] but in limited military studies, there is not a clear association. In male Royal Marine recruits, BMD at the lumbar spine, femoral neck, and whole body were found to be lower in those who sustained SFx.[12] Low BMD at the lumbar spine conferred a 4-fold greater SFx risk compared to normal lumbar spine BMD. The cases and controls were tightly matched in this study, and the homogenous population of recruits may demonstrate the strength in this finding.[12]

A 2013 study of USMA cadets found that average BMD in female recruit SFx cases was decreased at the spine, total hip, and femoral neck compared to those in female recruits without SFx.[3] This study did not find these associations in male recruits and concluded that BMD is not a useful screening tool. The significant findings in female recruits are important, however, especially considering this subgroup's increased SFx risk. BMD values at the spine, total hip, femoral neck, and calcaneus were also lower in female cases and controls when compared to male cases and controls, respectively.[3]

A 2019 study of U.S. Army female recruits corroborated an expected finding that BMD increased following training, as well as total bone volume and trabecular and cortical thickness in the tibia.[25] These findings illustrate how basic training activity increases tibial loading, requiring adaptations that were not present before training.[25]

CONCLUSIONS

Awareness and understanding of SFx risk factors and how they apply to recruits individually is crucial for the multidisciplinary team. As discussed in Part I of this series, screening is important for primary prevention. Knowledge of risk factors (e.g., nutritional deficiency, fitness level, training program design, equipment, components of bone strength, and patient sex) can guide stratification. The high-risk subgroup of female recruits deserves consideration to avoid the detrimental consequences of injury.

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None declared.

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