How Stress Fracture Incidence Was Lowered in the Israeli Army: A 25-yr Struggle

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ABSTRACT

FINESTONE, A., and C. MILGROM. How Stress Fracture Incidence Was Lowered in the Israeli Army: A 25-yr Struggle. *Med. Sci. Sports Exerc.*, Vol. 40, No. 11S, pp. S623–S629, 2008. In 1983, a 31% incidence of stress fractures was found among Israeli basic infantry recruits. **Purpose**: The purpose of this article is to chronicle the efforts of the Israeli Defense Forces to lower the stress fracture incidence and to present new data showing how reduction was finally achieved. **Methods**: A historical review of the steps taken over the past 25 yr to decrease stress fracture incidence in the Israeli Army is presented: risk factors for stress fracture were identified to create a risk profile and facilitate screening of recruits; modifications in army shoes were made; shock attenuating orthoses and biomechanical orthoses of various compositions were used; and the bisphosphonate risedronate was administered to recruits before and during basic training. In the latest intervention, the combined effect of a minimum nightly sleep requirement (6 h a night) and a decrease in recruits' cumulative marching and running on the incidence of stress fractures was evaluated among 276 infantry recruits. **Results**: A stress fracture risk profile was developed. It allows a recruit's stress fracture risk to be calculated before infantry training. Shoe modifications, orthoses, and pharmacological treatment with risedronate were not effective in lowering the incidence of stress fractures. The minimum sleep regimen and the reduced cumulative marching lowered the incidence of stress fractures by 62% (from 30.8% to 11.6%) and decreased their severity as compared with the 1983 baseline study. **Conclusion**: After failing in prior interventions, a more than 60% decrease in stress fracture incidence was achieved by enforcing a minimum sleep regimen and lowering the cumulative marching during infantry training. These changes did not affect the quality of the training or the soldiers' combat readiness.
Key Words: BONE, FATIGUE FRACTURE, INTERVENTION, RISK FACTOR, MILITARY, SLEEP DEPRIVATION

The goal of infantry training is to produce a combat soldier. Physical performance, endurance, mental conditioning, and combat skills must be built at a minimum risk of injury. Most of the injuries sustained by infantry trainees are secondary to overuse and not to acute trauma. In the first Israeli prospective study of the epidemiology of overuse injuries among infantry recruits in 1983, an alarming 31% incidence of stress fractures was found during 14 wk of infantry basic training (20). Subsequent studies, using the same materials and methods, found the incidence to be in the range of 23% to 24% (18,27). These findings spurred efforts to find ways to decrease the incidence of stress fractures.

The purpose of this article is to chronicle the efforts made by the Israeli Defense Forces over the past two decades to lower the incidence of stress fractures among infantry soldiers and to present new data showing how reduction was finally achieved.

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STEPS TAKEN TO LOWER THE INCIDENCE OF STRESS FRACTURES

I. Identification of potential risk and preventive factors for stress fracture

The first step toward the lowering of the incidence of stress fractures was to identify possible risk factors for their development (9,11). In spite of a high incidence of overuse injuries, most infantry recruits finish their basic training without injury. It was thought that those who sustained stress fractures might have either intrinsic anatomic or physiological factors and/or deficiencies in their lifestyle such as lack of physical activity before army service, which increased the risk for stress fracture.

In an initial study, before beginning basic training, infantry recruits were assessed for factors considered to have a possible relationship with the incidence of stress fractures (11). Some of the factors studied were chosen based on prior published articles (15,24,26), others due to biomechanical considerations. Recruits were then followed during 14 wk of basic training and were actively examined by a team of physicians every 2 or 3 wk for the presence of overuse injuries. Recruits suspected of having stress fracture underwent bone scintigraphy evaluation.

Narrow tibias were found to be a risk factor for both tibial and femoral stress fractures (Table 1). The basis for the association between bone size and the risk for stress

TABLE 1. Overall incidence of stress fractures among infantry recruits according to tibial bone width.*

Stress Fractures	Bone Width: Narrow Bone (Width ≤26 mm)	Bone Width: Wide Bone (Width >26 mm)	Total
Number of soldiers without stress fractures (%)	69 (58.0)	130 (76.9)	199 (69.1)
Number of soldiers with stress fractures (%)	50 (42.0)	39 (23.1)	89 (30.9)
Total	119	169	288

* P value < 0.01

fracture can be found in basic engineering strength calculations. Diaphyseal bone can be idealized as a cylinder. For such a construct, the bending strength is proportional to the area moment of inertia, the rotational strength is proportional to the polar area of inertia, and the compression strength is proportional to the cross-sectional area. The polar and the area moments of inertia are proportional to the radius to the fourth power (r^4), and the cross-sectional area is proportional to the radius to the second power (r^2). Practically and assuming the same material properties, this means that if the diameter of a bone increases from 2 to 2.5 cm, then the bending and the rotational strength increases by 126% and the compression strength increases by 51%.

External rotation of the hip greater than 65° was found to be a risk factor for stress fractures (9,14) (Table 2). The basis for this association is not known. Narrow tibial bone size (11,12) and high external rotation of the hip (11,14) are independent risk factors for stress fracture. Their risk is cumulative. Combining them allows for effective profiling of recruits at high risk for stress fracture during infantry basic training (Fig. 1).

Recruits with true pes planus are routinely not admitted into Israeli army infantry service. When foot arch height was classified into categories of lower normal, normal, and high arch, low normal arch was found to be a protective factor for stress fractures in basic training (13). The arch type was assessed off weight bearing. A 10% incidence of stress fractures was found among recruits with low normal foot arches as opposed to 39.6% incidence among those with high arches (P < 0.05). Recruits whose foot arches were defined as average had a 31.3% incidence.

Recruits' age was found to be a risk factor for stress fractures during infantry basic training. Recruits who were

TABLE 2. Overall incidence of stress fractures among infantry recruits according to external rotation of the hip.*

Stress Fractures	Hip External Rotation: <65°	Hip External Rotation: >65°	Total
Number of soldiers without stress fractures (%)	149 (75.3)	47 (56.0)	196 (69.5)
Number of soldiers with stress fractures (%)	49 (24.7)	37 (44.0)	86 (30.5)
Total	198	84	282

* P value < 0.005.

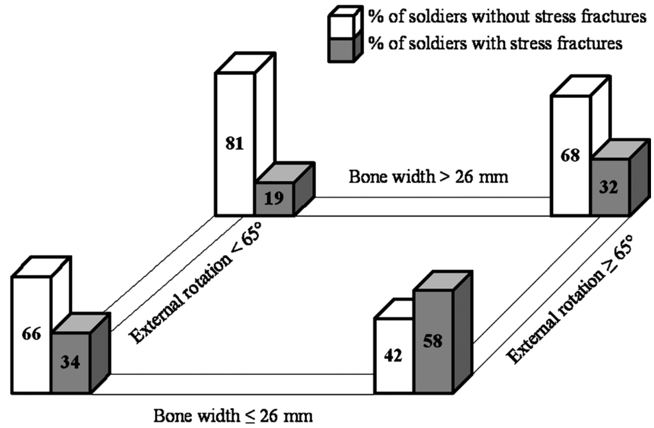

FIGURE 1—Cumulative stress fracture risk of tibial bone width and external rotation of the hip.

younger had a higher incidence of stress fractures. Risk decreased by 28% for every year increase of age between 17 and 26 years (17). This association can be explained by the fact that the bone reaches its maximum strength at the age of 25 to 26 years.

The type of physical activity of recruits before military induction was a major determinant for stress fracture risk in basic training. It was found that recruits who had played basketball with a frequency three times a week or more, for at least 2 yr before military induction, had a low risk for stress fractures in basic training (Table 3) (21,22). Long-distance running was not protective. The explanation is that whereas long-distance running involves the repetition of the same stride pattern over and over again, basketball is an activity with multiple force vectors. Assuming Wolff's law is true, basketball would be expected to strengthen bone against forces in multiple directions and running only to strengthen it for a limited number of force vectors.

When infantry basic trainees were followed through their subsequent year of infantry service, an interesting observation was made. Recruits who sustained femoral stress fractures in infantry basic training were found to be at a 25% higher risk to sustain stress fractures in future training when compared with recruits who did not sustain stress fractures in basic training. However, this association was not found to be true for tibial or metatarsal stress fractures (10).

Tibial bone mineral content and bone density as well as body habitus according to heath carter somatotypes were not found to be related to the incidence of stress fracture. Prebasic training aerobic physical fitness was not found to be related to the incidence of stress fractures (11).

The study and identification of risk factors allowed us to build a profile of an infantry recruit with a low risk for stress fracture. He should have wide bones, a low range of hip external rotation, a low-normal foot arch, be beyond his teens in age, and have played basketball regularly for more than 2 yr. Unfortunately, this profile is more of theoretical than of practical use. Motivated, physically and mentally capable candidates for infantry or special training forces are

TABLE 3. Incidence of stress fractures among recruits who played ball sports for 2 yr before induction into the army and those who did not play.

	1988			1990			1995		
Site	Played (N = 129), %	Did Not Play (N = 263), %	P Value	Played (N = 90), %	Did Not Play (N = 304), %	P Value	Played (N = 55), %	Did Not Play (N = 277), %	P Value
Tibia	4.7	23.2	0.001	12.2	20.7	0.07	3.6	14.8	0.024
Femur	7.8	10.7	0.363	1.1	6.9	0.035	0	10.1	0.014
All	13.2	28.9	0.001	16.7	26.97	0.046	3.6	18.8	0.05

not in an excess. So even if a candidate has a 40% risk for stress fracture, he still has a 60% chance of not developing a stress fracture in infantry training. Eliminating such a candidate *a priori* from infantry service would not seem to be warranted.

II. Modifications in footwear

The next effort to lower the incidence of stress fractures centered on shoe gear and orthoses. It was thought that training with shoe gear that had improved shock absorption at the foot ground interface could lower the incidence of stress fractures. If this hypothesis were true, it would have been possible to lower the incidence of stress fractures without any changes in the training. A series of prospective studies were carried out to study this hypothesis.

In the first study, the effect of training in basketball shoes instead of traditional army shoes was studied. Before the beginning of the training, two pairs of modified basketball shoes were given at random to 187 of the recruits. The other 203 recruits received standard lightweight infantry boots. The soldiers were not allowed to change shoe gear until the end of their training. Initially, the basketball shoes were judged by the soldiers to be more comfortable than army shoes. Once it rained, the soldiers changed their appraisal. The areas padding for comfort absorbed water, and the shoes became heavy and damp. During the 14 wk of training, 93 (24%) of 390 recruits had sustained a total of 140 stress fractures (18). Recruits training in a modified basketball shoe had a statistically significant lower incidence of metatarsal stress fractures (P = 0.03) and non-stress-fracture–related foot overuse injuries (P = 0.001) compared with recruits using standard infantry boots, but their overall incidence of overuse injuries was not reduced.

Foot orthoses are devices that help the foot to function better. They may be divided into four basic types: devices that reduce impact and cushion the foot, arch supports, those used to relieve pressure, and biomechanical, custom-fabricated shoe orthotics that are designed to bring the foot into proper alignment as it strikes the ground and thereby improve function.

The first foot orthoses studied were prefabricated, composed of a polyolefin module covered with cambrel. The heel, posted in 3° of varus, was composed of PPT® (open cell urethane foam) covered with a protective plate. This orthotic was designed to serve both as a shock absorber and as an arch support. In a prospective randomized study (27), 113 recruits using the orthotic device were compared with a control group of 152 without devices. The effect of the orthotic device on the incidence of stress fractures was evaluated separately for soldiers with high arch feet and soldiers with low-normal arch feet. In the high arch population, the femoral stress fracture incidence was 5.1% among the subjects wearing the device and 15.5% among those not using it (P < 0.003). In the low arch population, an opposite trend was observed. The femoral fracture incidence among soldiers using the device was 7.9%, whereas in the nonusers it was 2.6%. No significant differences in the incidence of tibial and metatarsal stress fractures were found between soldiers who did and who did not use the device in either group, high or low foot arch.

It was then thought that a custom biomechanical orthotic might be more effective in lowering the incidence of stress fractures. In a subsequent study (7), infantry recruits were randomly assigned to three groups. The subjects in the first group were given semirigid biomechanical orthotics made of polypropylene. The subjects in the second group received soft biomechanical orthotics fabricated from three layers of polyurethane of different density (grades 80 upper layer, 60 middle layer, and 80 lower layer). The subjects who formed the third group were controls and were not given orthotics. Recruits were reviewed biweekly during 14 wk of basic training. The incidence of stress fractures was 10.7% for the soft biomechanical orthotic, 15.7% for the semirigid biomechanical orthotic, and 27% for the control group. According to the per-protocol analysis, these differences were significant but not by intention-to-treat analysis. The soft biomechanical orthotics were better tolerated by recruits than the semirigid devices. It seemed that we might have found a simple means to lower the incidence of stress fractures.

To confirm these findings, an additional prospective study was done. Eight hundred and seventy-four infantry recruits were randomized into four orthotic groups: soft custom, soft prefabricated, semirigid biomechanical, and semirigid prefabricated (8). The effects of the orthotic devices on the incidence of stress fractures, ankle sprains, and foot problems were studied during 14 wk of basic training. There was a significant dropout from the study due to discomfort with the orthotics. A statistically significantly lower number of recruits, given soft prefabricated orthoses, finished basic training in their assigned devices (53%) than that in the soft custom group (72%), in the semirigid biomechanical group (75%), and in the semirigid prefabricated group (82%) (P = 0.003). There was no statistically significant difference in the overall incidence of stress fractures, ankle sprains, or foot problems between recruits using the different types of orthoses.

In a subsequent study, *in vivo* tibial strain measurements were made in nine members of a special forces police unit to determine whether the use of biomechanical orthotics lowers tibial strains during both walking and running and whether it is dependent on the type of shoe worn (6). Measurements were made during treadmill walking at 5 $\text{km}\cdot\text{h}^{-1}$ and then during serial 2-km treadmill runs at 13 $\text{km}\cdot\text{h}^{-1}$ with running shoes with and without the orthoses and during serial 1-km runs with army boots with and without the orthoses. When soft or semirigid biomechanical orthotics were worn together with army boots, the tibial peak-to-peak strains during walking were significantly lowered. Soft orthotics also significantly lowered the tension and compression strain rates when worn with army boots during walking. During running, however, semirigid orthotics significantly increased the compression and the tension strain rates when worn with army boots. This indicates that the use of biomechanical orthotics may not be beneficial for infantry soldiers whose training includes significant amounts of running.

When either soft or semirigid orthoses were worn with the running shoes during treadmill walking or running, no significant differences were observed in either peak-to-peak strains or strain rates.

On the basis of the abovementioned trials, it was concluded that changes in the military boots and use of orthotics could not have a major effect on the incidence of stress fractures in military recruits.

III. Pharmacological administration

Bone has been shown to have a high resistance to mechanical loading. In *ex vivo* laboratory bench testing, cortical bone fails in fatigue within 10^3 to 10^5 loading cycles when strains are between 5000 and 10,000 $\mu\varepsilon$ (5). When the strain level is lowered to 3000 $\mu\varepsilon$ in uniaxial tension, bone fails at 10^6 cycles. Strains in the physiologic range of 1000 to 1500 $\mu\varepsilon$ in *ex vivo* studies have been shown to cause fatigue and microdamage but not to result in complete fracture of cortical bone even after 37 million loading cycles (25).

In an effort to better understand the etiology of stress fractures, we undertook a series of *in vivo* human strain gauge studies. In our first study, a surface strain gauge was mounted to the human tibia of two subjects. The *in vivo* measurements showed that strains do not exceed 2000 $\mu\varepsilon$ even during very vigorous physical activity (4). In a second experiment, the database was expanded to six additional subjects with measurements made from instrumented bone staples placed in the tibia (19). The results for various activities were similar to the initial experiment and are shown in Figures 2 and 3.

The discrepancy between the results of the laboratory bench studies and the *in vivo* human bone strain recordings led us to the hypothesis that tibial and femoral stress fractures are mediated by bone remodeling. According to this hypothesis, when bone is subjected to strains or strain rates that are higher than usual or have a different distribution, it remodels to repair microdamage and to strengthen itself. During the initial resorption phase of remodeling, the bone is transitorily weakened and microdamage can accumulate, leading to stress fracture. We speculated that short-term suppression of bone turnover using bisphosphonates can prevent the initial loss of bone during the remodeling response to high bone strain and strain rates and potentially prevent stress fracture.

A randomized, double-blind, placebo-controlled trial of 324 new infantry recruits known to be at high risk for stress fracture was conducted by Milgrom et al. (16). Recruits were given a loading dose of 30 mg of risedronate or

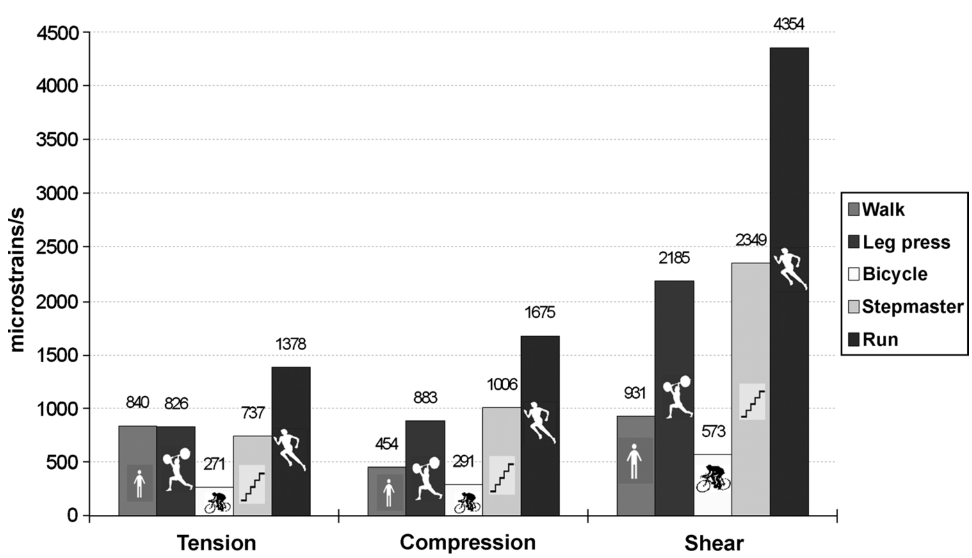

FIGURE 2—Human bone principal strains measured *in vivo* during various exercise activities.

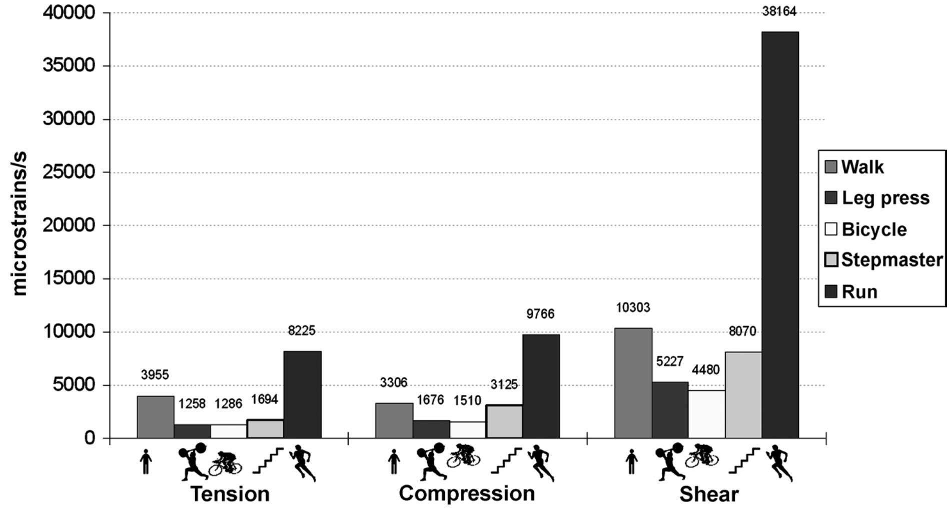

FIGURE 3—Human bone principal strain rates measured *in vivo* during various exercise activities.

placebo daily for 10 doses during the first 2 wk of basic training and then a once a week maintenance dose for the following 12 wk. Recruits were monitored by biweekly orthopedic examinations for signs of stress fractures during 15 wk of basic training. Suspected stress fractures were evaluated with bone scintigraphy. According to the intention-to-treat analysis and the per-protocol analysis, there was no statistically significant difference in the tibial, femoral, metatarsal, or total stress fracture incidence between the treatment group and the placebo group. Prophylactic treatment of recruits with a maintenance dose of risedronate for osteoporosis was ineffective in lowering the incidence of stress fractures. The reason of this lack of effectiveness was investigated by Barrett et al. (1) in an animal model. They studied the effect of short-term treatment with alendronate on ulnar bone adaptation to cyclic loading in rats. In their study, preemptive treatment with alendronate did not protect the ulna from fatigue during cyclical loading. They found evidence that the alendronate treatment likely acts to inhibit remodeling of microcracking and remodeling of any associated stress fracture callus. The studies of Milgrom et al. (16) and Barrett et al. (1) indicate that prophylactic treatment with bisphosphonates at the dose used to treat osteoporosis has no role in prevention of stress fractures and may even have a detrimental effect.

IV. Changes in the training program

The next attempt at lowering stress fracture incidence involved the amount of sleep recruits received. Ben-Sasson et al. (2) studied the effect of sleep deprivation on infantry recruits' bone metabolism. Soldiers were divided into three groups: 1) soldiers who were sleep deprived for 63 h; 2)

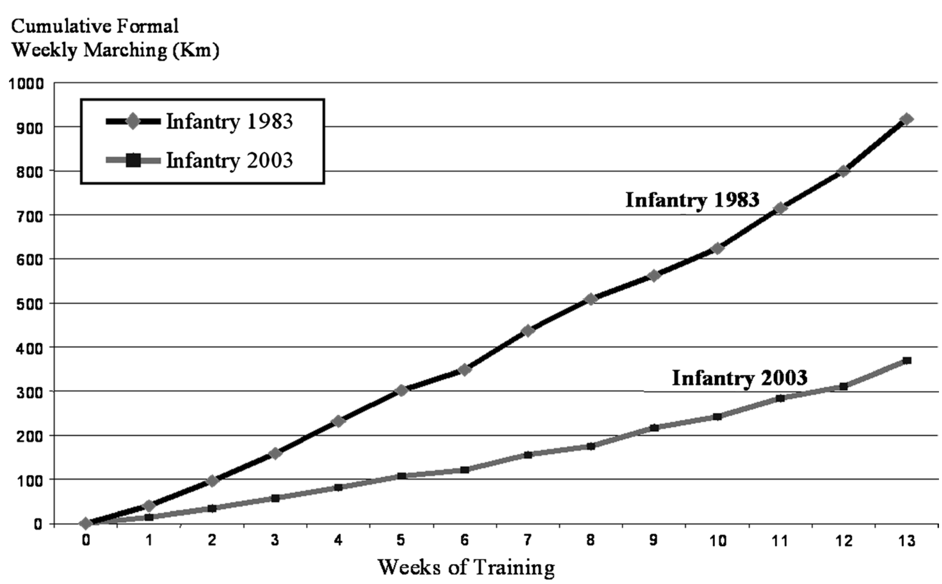

FIGURE 4—Comparison of cumulative formal marching in 1983 and 2003 infantry training.

soldiers who slept in a vertical position 6 h for three consecutive nights; and 3) soldiers who slept 6 h a night horizontally for three consecutive nights. The bone resorption markers of those recruits who slept for 6 h horizontally did not increase above baseline measurements. Among sleep-deprived recruits, markers increased by 170%. Among recruits who slept in the vertical position, markers increased by 68%. When the data were further analyzed, it was found that not all participants in the sleep-deprivation or vertical sleep group reacted to the inadequate sleeping regimen. Forty percent of both groups were "responders" with altered bone markers and 60% were "nonresponders" with no changes in markers. On the basis of this data, it was decided to strictly enforce a minimum 6-h sleep requirement during infantry basic training. Exceptions to the rule were made for night guarding, night marches, and during 2 wk of special field training. Previously recruits often slept 3 to 4 h a night.

The second change made in the training was a decrease in recruits' cumulative marching and running (Fig. 4). It has been previously observed that the majority of stress fractures occurred during basic training and not during subsequent, more demanding advanced infantry training. This indicates that by the time infantry recruits have finished basic training, their bone is already better adapted to cope with high loads placed on them. In thoroughbred racehorse training, increased galloping distance has been found to be related to increased stress fracture incidence (3). Training that included more short periods of breezing (fast running) was found to protect against stress fractures. Nunamaker (23) showed in the horse model that intense exercise turns off bone remodeling and rest stimulates remodeling. The findings of these studies support the decision to modify basic training and to shift more of the demanding bone loading activities such as running and marching to advanced infantry training.

To assess the effect of these two training changes on the incidence of stress fractures in basic training, a prospective study of 308 infantry recruits was conducted. The study was approved by the institutional review board. A prebasic training evaluation was performed over a 4-d period. The recruits were surveyed for the presence of known risk factors for stress fractures. Preinduction participation in sports was assessed by an investigator-administered oral questionnaire. Subjects' height, weight, tibia length, hip external rotation, and foot arch height, already known to be risk factors for stress fracture, were measured. Physical fitness was assessed by the Bar-Or fitness test. The test is composed of three variables: the time of a 2-km run, the maximum number of push-ups, and the maximum number of sit-ups performed by the recruit.

During basic training, recruits were reviewed by the orthopedic team every 2 wk for the presence of subjective and objective signs of lower extremity stress fracture. Recruits with a suspicion of stress fracture were given 2 wk of relative rest. If their symptoms persisted, those with a suspicion of metatarsal stress fractures were sent for x-rays. In cases of suspected tibial, femoral, femoral condyle, or navicular fracture, the recruits underwent bone scan. Bone scans were read based on a 1 to 4 stress fracture scale described by Zwas et al. (28). At the end of basic training, all recruits had a final orthopedic examination. The findings were compared with the data from the baseline 1983 Israeli infantry stress fracture study.

Table 4. Comparison of stress fractures incidence by sites and grades before (1983) and after (2003) the modifications of the training program (minimum sleep requirement and decreased cumulative marching).

Variable	1983	2003
Overall incidence of stress fractures (%)	30.8	11.6
% of stress fractures—tibia	56.1	35.7
% of stress fractures—femur	33.6	50.0
% of stress fractures—metatarsus	7.6	8.9
% of stress fractures—other sites	2.7	5.4
% grades 1–2 stress fractures	52.8	91.1
% grades 3–4 stress fractures	47.2	8.9

Written informed consent was obtained from 308 recruits. Two hundred and seventy-six of them finished basic training (mean age = 18.96 yr, range = 18–28 yr). The incidence of stress fractures was 11.6% as compared with 30.8% in the 1983 study with standard training (Table 4). As a result of the modified training, there was also a marked shift toward lower grade stress fractures (less than 9% of the fractures were grade 3 or 4 vs 47% in 1983), and the femur replaced the tibia as the most frequent site of stress fracture. There were no scintigraphic grade 3 or 4 tibial or femoral stress fractures.

Despite these modifications in the training program, the recruits continued to increase their bone strength, and their combat readiness was not affected. Tibial ultrasound speed of sound, a measurement that reflects bone strength, increased significantly by 0.5% among recruits who finished infantry training and did not sustain stress fracture.

SUMMARY AND CONCLUSIONS

As a result of systemic study of stress fractures during the past 25 yr, the incidence of stress fractures in Israeli infantry basic training has been reduced from 31% to less than 10%. Additionally, the severity of the stress fractures as judged by their scintigraphic uptake has been reduced. This reduction was principally achieved through a modified training program with reduced cumulative marching and an enforced sleep regimen accompanied by an increased awareness of the problem of stress fractures by the staff. The separate effects of these two modifications of the training program were not evaluated, only their combined influence on stress fracture incidence. This solution has no economic cost nor does it sacrifice the quality of the infantry soldiers as fighters.

Another result of the 25-yr "quest" was the development of a new infantry boot made of softer leather, with a wider shoe last and a removable shock absorbing orthotic. The shoe was designed for increased soldier comfort, to decrease foot problems, to decrease metatarsal stress fractures, but not as a means to lower the overall incidence of stress fractures. Recent combat experience has shown the vulnerability of infantry soldiers, moving in armored vehicles to missile attacks and to roadside explosive charges. This experience increases the need for infantry soldiers in combat to be able to reach even distant positions on foot while carrying gear sufficient for several days. Infantry basic training will have to be correspondingly changed to condition recruits to carry these increased loads. Future research will be centered on ways to achieve this conditioning while minimizing stress fracture risk.

The opinions and assertions in this article are those of the authors and do not necessarily represent official interpretation, policy, or views of the US Department of Defense or the Israeli Defense Forces.

REFERENCES

1. Barrett JG, Sample SJ, McCarthy J, Kalscheur VL, Muir P, Prokuski L. Effect of short-term treatment with alendronate on ulnar bone adaptation to cyclic fatigue loading in rats. *J Orthop Res*. 2007;25:1070–7.
2. Ben-Sasson SA, Finestone A, Moskowitz M, et al. Extended duration of vertical position might impair bone metabolism. *Eur J Clin Invest*. 1994;24:421–5.
3. Boston RC, Nunamaker DM. Gait and speed as exercise components of risk factors associated with onset of fatigue injury of the third metacarpal bone in 2-year-old thoroughbred race-horses. *Am J Vet Res*. 2000;61:602–8.
4. Burr DB, Milgrom C, Fyhrie D, et al. In vivo measurement of human tibial strains during vigorous activity. *Bone*. 1996;18:405–10.
5. Carter DR, Caler WE, Spengler DM, Frankel VH. Fatigue behavior of adult cortical bone: the influence of mean strain and strain range. *Acta Orthop Scand*. 1981;52:481–90.
6. Ekenman I, Milgrom C, Finestone A, et al. The role of biomechanical shoe orthoses in tibial stress fracture prevention. *Am J Sports Med*. 2002;30:866–70.
7. Finestone A, Giladi M, Elad H, et al. Prevention of stress fractures using custom biomechanical shoe orthoses. *Clin Orthop Relat Res*. 1999;360:182–90.
8. Finestone A, Novack V, Farfel A, Berg A, Amir H, Milgrom C. A prospective study of the effect of foot orthoses composition and fabrication on comfort and the incidence of overuse injuries. *Foot Ankle Int*. 2004;25:462–6.
9. Finestone A, Shlamkovitch N, Eldad A, et al. Risk factors for stress fractures among Israeli infantry recruits. *Mil Med*. 1991;156:528–30.
10. Giladi M, Milgrom C, Kashtan H, Stein M, Chisin R, Dizian R. Recurrent stress fractures in military recruits. One-year follow-up of 66 recruits. *J Bone Joint Surg Br*. 1986;68:439–41.
11. Giladi M, Milgrom C, Simkin A, Danon Y. Stress fractures. Identifiable risk factors. *Am J Sports Med*. 1991;19:647–52.
12. Giladi M, Milgrom C, Simkin A, et al. Stress fractures and tibial bone width. A risk factor. *J Bone Joint Surg Br*. 1987;69:326–9.
13. Giladi M, Milgrom C, Stein M, Kashtan H, Margulies J, Chisin R. The low arch, a protective factor in stress fractures. A prospective study of 295 Military recruits. *Orthop Rev*. 1985;14:81–4.
14. Giladi M, Milgrom C, Stein M, et al. External rotation of the hip. A predictor of risk for stress fractures. *Clin Orthop Relat Res*. 1987;(216):131–4.
15. Gilbert RS, Johnson HA. Stress fractures in military recruits. A review of twelve years' experience. *Mil Med*. 1966;131:716–21.
16. Milgrom C, Finestone A, Novack V, et al. The effect of prophylactic treatment with risedronate on stress fracture incidence among infantry recruits. *Bone*. 2004;35:418–24.
17. Milgrom C, Finestone A, Shlamkovitch N, et al. Youth is a risk factor for stress fracture. A study of 783 infantry recruits. *J Bone Joint Surg Br*. 1994;76:20–2.
18. Milgrom C, Finestone A, Shlamkovitch N, et al. Prevention of overuse injuries of the foot by improved shoe shock attenuation. A randomized prospective study. *Clin Orthop Relat Res*. 1992;(281):189–92.
19. Milgrom C, Finestone A, Simkin A, et al. In-vivo strain measurements to evaluate the strengthening potential of exercises on the tibial bone. *J Bone Joint Surg Br*. 2000;82:591–4.
20. Milgrom C, Giladi M, Stein M, et al. Stress fractures in military recruits. A prospective study showing an unusually high incidence. *J Bone Joint Surg Br*. 1985;67:732–5.
21. Milgrom C, Shaffer R. Exercise programs that prevent or delay the onset of stress fracture. In: Burr DB, Milgrom C, editors. *Musculoskeletal Fatigue and Stress Fractures*. Boca Raton (FL): CRC Press; 2001. p. 247–57.
22. Milgrom C, Simkin A, Eldad A, Nyska M, Finestone A. Using bone's adaptation ability to lower the incidence of stress fractures. *Am J Sports Med*. 2000;28:245–51.
23. Nunamaker DM. Relationships of exercise regimen and race-track surface to modeling/remodeling of the third metacarpal bone in two year old thoroughbred racehorses. *Vet Comp Orthop Traumatol*. 2002;4:195–9.
24. Protzman RR, Griffis CG. Stress fractures in men and women undergoing military training. *J Bone Joint Surg Am*. 1977;59:825.
25. Schaffler MB, Radin EL, Burr DB. Long-term fatigue behavior of compact bone at low strain magnitude and rate. *Bone*. 1990;11:321–6.
26. Scully TJ, Besterman G. Stress fracture—a preventable training injury. *Mil Med*. 1982;147:285–7.
27. Simkin A, Leichter I, Giladi M, Stein M, Milgrom C. Combined effect of foot arch structure and an orthotic device on stress fractures. *Foot Ankle*. 1989;10:25–9.
28. Zwas ST, Elkanovitch R, Frank G. Interpretation and classification of bone scintigraphic findings in stress fractures. *J Nucl Med*. 1987;28:452–7.