High Injury Rates Among Female Army Trainees
A Function of Gender?
Nicole S. Bell, ScD, MPH, Thomas W. Mangione, PhD, David Hemenway, PhD, Paul J. Amoroso, MD, MPH, Bruce H. Jones, MD, MPH

Background: Studies suggest that women are at greater risk than men for sports and training injuries. This study investigated the association between gender and risk of exercise-related injuries among Army basic trainees while controlling for physical fitness and demographics.

Methods: Eight hundred and sixty-one trainees were followed during their 8-week basic training course. Demographic characteristics, body composition, and physical fitness were measured at the beginning of training. Physical fitness measures were taken again at the end of training. Multivariate logistic regression analysis was used to evaluate the association between gender and risk of injury while controlling for potential confounders.

Results: Women experienced twice as many injuries as men (relative risk [RR] = 2.1, 1.78–2.5) and experienced serious time-loss injuries almost 2.5 times more often than men (RR = 2.4, 1.92–3.05). Women entered training at significantly lower levels of physical fitness than men, but made much greater improvements in fitness over the training period.

In multivariate analyses, where demographics, body composition, and initial physical fitness were controlled, female gender was no longer a significant predictor of injuries (RR = 1.14, 0.48–2.72). Physical fitness, particularly aerobic fitness, remained significant.

Conclusions: The key risk factor for training injuries appears to be physical fitness, particularly cardiovascular fitness. The significant improvement in endurance attained by women suggests that women enter training less physically fit relative to their own fitness potential, as well as to men. Remedial training for less fit soldiers is likely to reduce injuries and decrease the gender differential in risk of injuries.


Introduction

For most injury categories, men are at greater risk than women.1 However, for sports and training injuries, studies suggest that when exposure is controlled, women are actually at greater risk than men. This has been documented in a number of civilian as well as military studies.2–12 Low physical fitness, as measured by sit-ups, run times, and body composition (e.g., high percent body fat) have also been identified as risk factors for training injuries in the military.12–15 A few studies have suggested that female basic trainees are less physically fit than their male counterparts on entry to basic training.10,16,17 It is not clear how much the higher incidence of injuries among female trainees can be attributed to their lower level of fitness.

The primary purpose of this study is to examine the relative rates of injury for male and female Army trainees, controlling for physical fitness.

Methods

Data

A cohort of 861 Army trainees (509 men and 352 women) were followed over the course of the standard 8-week basic combat training (BCT) course. The population of potential study volunteers included all women entering female training companies formed for one month during the fall of 1988. One out of four
male companies, selected on the basis of its proximity to the women’s units, was also included for comparison.

All potential volunteers were briefed on the study and offered the opportunity to participate ($n = 1075$); 93% volunteered for the study and signed consent forms ($n = 1002$). Due to scheduling difficulties, anthropometric measures could not be obtained on 14% of these volunteers, precluding them from the analysis. Thus, data for this analysis were available for 861 trainees (86% of volunteers).

Trainees were administered a baseline screening survey that included measures of demographic characteristics such as gender, age, and race/ethnicity. In addition, study staff assessed volunteers’ body composition and fitness. Body composition measures included height, weight, and percent body fat. Fitness measures included flexibility, muscle strength, muscle endurance, and aerobic fitness.

Percent body fat was estimated by a series of circumference measurements. Flexibility was measured by the use of a Bender-Box, which assesses range of motion in a sitting position stretching over the toes. Muscle strength was estimated through an isometric test of maximum hand grip force. Muscle endurance and aerobic fitness were measured through the initial Army physical fitness test, comprised of maximal push-ups and sit-ups in 2 minutes and 1-mile run times. Fitness was also assessed at the end of training by timed maximal push-ups and sit-ups in 2 minutes and a 2-mile run.

To assess improvements in aerobic fitness, the end of training 2-mile run times were converted to their 1-mile run time equivalents. Run times are highly correlated with maximum oxygen consumption ($VO_2$ max), a measure of aerobic capacity. Using a table listing $VO_2$ max and run times for given distances, 1-mile run times and equivalent 2-mile run times were matched using their corresponding $VO_2$ max values.

Medical records for the training period were reviewed every 2 to 3 weeks and all injury diagnoses transcribed. Diagnoses were made by clinic physicians who were blinded to patients’ participation in the study. Injury occurrence was defined as any condition causing a trainee to seek medical care that also resulted in an injury diagnosis. An injury leading to 1 or more days of lost duty was used as a measure of serious injury.

**Analysis**

For analysis, all subjects were split into one of five roughly equal-sized groups (quintiles) based on performance, from low to high levels. Since lower fitness is associated with higher injury risk, the most fit groups were used as the low-risk comparison group for analyses. Continuous fitness and body composition variables were grouped into quintiles to facilitate analysis and interpretation of findings.

Chi-square analysis was used to test the significance of risk ratios and the Mantel-Haenszel chi-square for trend was used to test for linear associations. Multivariate logistic regression models were used to evaluate the association between gender and risk of injury while controlling for the effects of fitness and demographic characteristics. Because body composition (weight and height) is so highly correlated with gender, it was not included in the multivariate models.

**Results**

The average age for male and female trainees was 20. Male trainees were more likely to be Caucasian than female trainees (men were 58% Caucasian, 33% African American, and 9% other; women were 43% Caucasian, 48% African American, and 9% other). Table 1 describes body composition and fitness characteristics of the male and female study participants. Men exhibited significantly higher entry-level measures of physical fitness than women on all measures except flexibility.

At the end of the training cycle, men still did more pushups and ran faster than women, but women narrowed the gap considerably, particularly through their sit-up performance (Figure 1 and Table 1). Women’s sit-up scores improved by 98%, versus a 44% improve-
ment for men; pushup scores improved by 156% compared to 54% for men. Women’s aerobic fitness, as measured by run times converted to VO₂ max scores, improved by 23% compared to only 16% for men.

Table 2 shows the cumulative incidence of one or more injuries for men and women. Women experienced about twice as many injuries overall as men. Their risk for more serious time-loss injuries was even greater at almost 2.5 times the risk of the male trainees. Most injuries for men and women were to the lower extremity (foot, lower leg).

Figure 2 displays the association between injury and aerobic fitness (run times). The figure depicts a step-wise significant trend (chi-square trend statistic = 87.9, $p < 0.000$) of higher risk of injury for successively lower levels of aerobic fitness (i.e., slower run times). The slowest runners had almost 3.5 times greater risk of experiencing an injury than the fastest runners.

Table 3 shows the gender and injury relationship stratified by aerobic fitness (run times). For the fast trainees, the relative risk of injury for women versus men was near 1 (RR = 1.04, $p = 0.78$). The injury risks for women were close to the risks for men within each quintile of run time, which suggests that aerobic fitness explains much of the injury risk differential.

The results of a logistic regression model of one or more injuries regressed on gender, physical fitness, and other demographic factors are found in Table 4. Gender was not significant when physical fitness, age, and race/ethnicity were controlled. Slow run time was the only significant predictor of injury. We also examined the association between gender, fitness, demographic factors, and risk of a time-loss injury (table not shown). Again, gender was not significant ($p = 0.62$), while run time was ($p = 0.04$; RR for slowest run time quintile = 3.72, 95% confidence interval [CI] 1.64–8.45). Caucasian race/ethnicity was also a significant risk factor for time-loss injuries (RR = 2.13, 95% CI 1.37–3.32 Caucasian, compared to African American referent group). Poor sit-up performance bordered on significant ($p = 0.05$).

**Discussion**

The crude injury rates indicated that women were at higher injury risk than men. The fitness-adjusted injury rates, however, showed no significant gender differ-

<table>
<thead>
<tr>
<th>Injury type</th>
<th>Men</th>
<th>Women</th>
<th>Relative risk*</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or more injuries</td>
<td>27%</td>
<td>57%</td>
<td>2.1</td>
<td>(1.78–2.50)</td>
</tr>
<tr>
<td>Time-loss injury</td>
<td>17%</td>
<td>41%</td>
<td>2.4</td>
<td>(1.92–3.05)</td>
</tr>
</tbody>
</table>

*Relative risk of injury for women over men; results from single-variable logistic regression models. CI, confidence interval.
ence. Thus, much of the gender–injury relationship appears to be explained by physical fitness, in particular aerobic fitness, as opposed to gender per se.

This is an important finding, particularly given the excess injury burden experienced by women in physically rigorous training programs coupled with the need to maintain a healthy, fit, injury-free fighting force. These results suggest that gender per se is not as good an indicator of injury risk as overall physical fitness, and therefore the excess risk women experience may be reduced through modified training programs.

The observed associations between injury and run times have a theoretical scientific basis. Most injuries were to the lower extremity, related to weight-bearing activities, so run time, as a marker for weight-bearing fitness, is particularly relevant to predicting these types of injuries.8,14 In addition, run times have been shown to correlate very highly (r > 0.80) with laboratory measures of aerobic capacity (VO2 max).18 Aerobic capacity, a reflection of the body's ability to use oxygen when physically challenged, may be a good measure of overall conditioning or physical fitness.24

Women had smaller variances than men in mean values for most demographic, body composition, and fitness measures. For sit-up scores and run times, however, women had larger standard deviations than men and a broader range of fitness scores. This suggests that perhaps these two variables were better discriminators of overall physical fitness for women than the other variables. This may help explain why run times were significant in both the multivariate model predicting one or more injuries and the model predicting time-loss injuries, and why sit-ups bordered on being significant (p = 0.05) in the multivariate model predicting time-loss injuries.

Military training populations offer advantages for the study of gender and injury: first, the historical incidence of injuries is high; and second, the regimented daily activities tend to equalize risk exposures for men and women. Men and women complete essentially identical training objectives, live under similar conditions, adhere to the same daily schedules, are offered the same diet, and have the same access to health care. Many potential confounders of the gender and injury relationship are thereby eliminated because of this unique environment, or are controlled through the prospective study design.9,10,13,14,25–29

The demographic and fitness characteristics, as well as the injury rates of trainees in this study, were similar to previous military training studies.9–12,14,16 The association between physical fitness and injury was also consistent with past studies.10–14,25 This suggests that our findings are generalizable to other military training populations.

Military populations may also be more representative of the general population and represent a broader range of fitness levels than competitive athletes, the subjects of many civilian studies.24 Thus, these findings may also provide insight into understanding exercise and training injuries among young civilian adults.

There are some limits to these data and this study that should be noted. First, injuries were defined by

<table>
<thead>
<tr>
<th>Run time quintilea</th>
<th>Relative riskb</th>
<th>95% CI</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>1.04</td>
<td>(0.4–2.7)</td>
<td>0.78</td>
</tr>
<tr>
<td>Average</td>
<td>1.52</td>
<td>(1.0–2.3)</td>
<td>0.09</td>
</tr>
<tr>
<td>Slow</td>
<td>1.17</td>
<td>(0.8–1.7)</td>
<td>0.45</td>
</tr>
<tr>
<td>Slowest</td>
<td>1.37</td>
<td>(0.5–3.7)</td>
<td>0.81</td>
</tr>
</tbody>
</table>

aThe 1-mile run times are grouped according to speed into quintiles. The fastest quintile was too small for calculation of a relative risk—there was only one female trainee in that stratum.
bRR, relative risk of injury for women over men.

CI, confidence interval.

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Table 3. Gender and relative risk of injury stratified on aerobic fitness (1-mile run times) for female and male Army basic trainees

<table>
<thead>
<tr>
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<th>Relative riskb</th>
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<th>(p)</th>
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<td>0.45</td>
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<td>Slowest</td>
<td>1.37</td>
<td>(0.5–3.7)</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Table 4. Gender and risk of one or more training-related injuries, controlling for physical fitness, age, and race; results from multiple logistic regression analysis of female and male Army basic trainees

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Relative risk</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Men — —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>Women 1.14</td>
<td>(0.48–2.72)</td>
</tr>
<tr>
<td>Run time</td>
<td>Very fast —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>Fast 1.47</td>
<td>(0.68–3.18)</td>
</tr>
<tr>
<td></td>
<td>Average 1.54</td>
<td>(0.91–2.62)</td>
</tr>
<tr>
<td></td>
<td>Slow 2.52</td>
<td>(1.26–5.04)</td>
</tr>
<tr>
<td></td>
<td>Very slow 3.23</td>
<td>(1.59–6.58)</td>
</tr>
<tr>
<td>Sit-ups</td>
<td>Very high —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>High 1.05</td>
<td>(0.60–1.81)</td>
</tr>
<tr>
<td></td>
<td>Average 0.80</td>
<td>(0.44–1.44)</td>
</tr>
<tr>
<td></td>
<td>Low 1.15</td>
<td>(0.63–2.09)</td>
</tr>
<tr>
<td></td>
<td>Very low 1.51</td>
<td>(0.78–2.92)</td>
</tr>
<tr>
<td>Pushups</td>
<td>Very high —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>High 1.62</td>
<td>(0.90–2.29)</td>
</tr>
<tr>
<td></td>
<td>Average 1.19</td>
<td>(0.65–2.19)</td>
</tr>
<tr>
<td></td>
<td>Low 1.34</td>
<td>(0.66–2.71)</td>
</tr>
<tr>
<td></td>
<td>Very low 1.24</td>
<td>(0.54–2.88)</td>
</tr>
<tr>
<td>Strength</td>
<td>Very strong —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>Strong 1.41</td>
<td>(0.80–2.50)</td>
</tr>
<tr>
<td></td>
<td>Average 1.61</td>
<td>(0.90–2.88)</td>
</tr>
<tr>
<td></td>
<td>Weak 2.10</td>
<td>(0.88–5.04)</td>
</tr>
<tr>
<td></td>
<td>Very weak 2.11</td>
<td>(0.83–5.36)</td>
</tr>
<tr>
<td>Age</td>
<td>&lt;20 — —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>20–24 1.50</td>
<td>(1.00–2.23)</td>
</tr>
<tr>
<td></td>
<td>25+ 1.26</td>
<td>(0.69–2.31)</td>
</tr>
<tr>
<td>Race</td>
<td>African American — —</td>
<td>— —</td>
</tr>
<tr>
<td></td>
<td>Caucasian 1.31</td>
<td>(0.89–1.94)</td>
</tr>
<tr>
<td></td>
<td>Other 0.84</td>
<td>(0.40–1.79)</td>
</tr>
</tbody>
</table>

CI, confidence interval.
reporting to the health clinic. There may be potential
gender or race/ethnicity-related bias resulting from
self-selection to seek medical care. We conducted some
exploratory analysis to check for this potential bias by
comparing gender differences in risk for injuries that
are consistently recognized and treated, and which
offer little option for the injured soldier but to seek
treatment. We compared rates of fractures since this
condition can be confirmed with diagnostic tests and
because it is extremely difficult to continue training
with a fracture. Using this nondiscretionary injury
outcome only expanded the gender difference suggest-
ing that women were neither malingering nor more
likely than their male counterparts to seek care.

Second, there are no statistical tests for sameness.
Failure to find an association is not sufficient evidence
to claim gender and injury are independent. Thus, we
cannot prove that gender is totally unrelated to injury
risk, even though it was not statistically significant in the
multivariate model controlling for physical fitness.
Even if a much larger prospective study were to identify
statistically significant differences in risk of injury, it
seems unlikely that the differences would be clinically
significant.

Third, this analysis describes gender-based differ-
cences in physical fitness. But it is not possible to
determine whether or not remedial training would, in
fact, allow some or all women to improve their level of
fitness to a level consistent with the male trainees.
However, the substantial improvements in endurance
performance for women suggests that women enter
training less physically fit relative to their own fitness
potential as well as relative to men entering training.
Our results demonstrate that women improve their
levels of fitness at approximately twice the rate of men,
substantially narrowing the fitness gap over the 8-week
training period. This is consistent with the work of
Patton et al.\textsuperscript{17} and others who show that soldiers at
lower entry levels of fitness (as assessed by VO\textsubscript{2} max
scores than those in the middle or upper ranges of
entry-level fitness. While women may not, on average,
be able to perform at the same absolute level of fitness
as men, they can substantially improve their perfor-
mance with training.

In addition, women and men of the same level of
physical fitness can be expected to have similar injury
risks when performing similar physically demanding
tasks or training. Men and women with the fastest run
times were not statistically different from each other in
terms of their overall risk for injury. Likewise, the very
slowest groups of men and women also experienced
similar injury rates. These results suggest that women
and men initiating a vigorous physical training or
exercise program, who exhibit low levels of physical
fitness, are more likely to be injured by training activi-
ties, but will also improve their level of fitness more
rapidly than their more fit peers.

Conclusions

Our results suggest that the key risk factor for training
injuries is physical fitness, particularly cardiovascular
fitness (run times). Gender, after controlling for fit-
ness, is not significantly associated with training-related
injury, while fitness, a covariate of gender, is. In the
early phase of training it may be wise to assign trainees to
fitness-appropriate levels of training and progress slowly
to more advanced training as their fitness improves.

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ance. The contents of this paper are the sole responsibility of
the authors and do not necessarily represent the official views
or policies of the U.S. Army.

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