Physical Fitness, Age, and Injury Incidence in Infantry Soldiers

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Injuries are a common occurrence in young, active civilian and military populations. This study examined injury incidence and the association of musculoskeletal injuries with age and physical fitness in soldiers. Subjects were a cohort of 298 male soldiers assigned to an infantry battalion in Alaska. The soldiers' ages were obtained from the battalion records and their physical fitness was assessed from 2-mile run times, sit-ups, and push-ups. Injuries were documented from a retrospective review of the soldiers' medical records for a 6-month period (October to March) before the fitness testing. Fifty-one percent of the soldiers suffered one or more injuries. The most common injury diagnosis was musculoskeletal pain, followed by strains, sprains, and cold-related injuries. Soldiers experienced a total of 212 separate injuries, which resulted in 1764 days of limited duty. The crude annualized injury rate was 142 injuries per 100 soldiers (one soldier could experience more than one type of injury). The proportion of soldiers injured decreased as age increased. Slower 2-mile run times and fewer sit-ups were associated with a higher incidence of musculoskeletal injuries. This study documents the injury incidence in infantry soldiers and identifies younger age and low physical fitness as potential risk factors for these injuries.

Injuries are a major medical problem in both civilian and military populations of the United States. Civilian statistics show that one of every four people suffers from injuries every year. Annually, more than 2 million Americans sustain injuries severe enough for hospitalization, and almost half are between 15 and 44 years of age.[1] Injuries are the fourth leading cause of death in Americans of all ages[2] and the leading cause of death in persons younger than age 44.[3]

These national statistics do not include military populations.[1] Injury rates may be expected to be high in the military because of the younger age of soldiers[4] and the vigorous nature of military training and operational activities. Several studies have shown a high incidence of injuries in basic training[5-9] and in large heterogenous military units that contain many occupational groups.[10-12] However, reliable information on injury incidence in specific military occupations (e.g., infantry, artillery, or armor soldiers) is still lacking.

It has been proposed that, in both civilian and military populations, the likelihood of activity-related injuries may be modified by a number of variables including age and physical fitness.[5,6,12-16] However, the evidence for these potential risk factors has been inconsistent and has not been firmly established, possibly because of methodologic differences among studies.

The purpose of this study was twofold: (1) to determine the incidence and types of injuries occurring in a sample of infantry soldiers and (2) to examine the associations of musculoskeletal injuries with age and physical fitness. Injury incidence was documented by examining the soldiers' medical records for a specific 6-month period. The age and physical fitness

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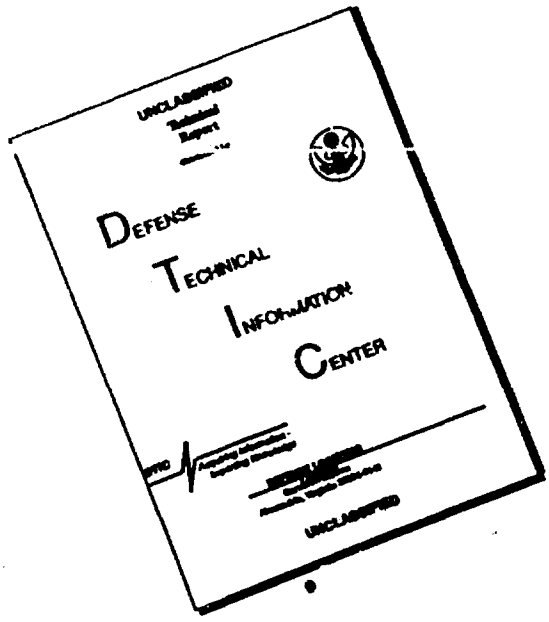

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of the soldiers were related to injury incidence.

Methods

Subjects

Subjects were male soldiers assigned to an infantry battalion at Fort Richardson, Alaska. Three hundred thirty-eight potential volunteers were verbally briefed in a single large group on the nature and purposes of the study. Of these, 335 soldiers (99%) gave their written, informed consent to participate. Three soldiers declined to take part. The process of informed consent was in accordance with the Army Surgeon General's Guidelines, as stipulated in Army Regulation 70-25.

Medical records on 298 (89%) of the volunteers were located in the Troop Medical Clinic for review. There were a variety of reasons for failure to locate missing records: the soldier was transferred to another unit between the time of the briefing and screening, the soldier was on temporary duty at another location, the soldier was referred to another hospital at the time of screening, or the soldier had not turned in his record to the clinic and could not be contacted.

Age and Physical Fitness Testing

A few days after the briefing, the age of the soldiers was obtained from the battalion personnel records. The Army Physical Fitness Test (APFT) was administered to measure the soldiers' aerobic and muscle strength fitness.[17,18] The APFT consisted of three events: a 2-mile run, sit-ups, and push-ups. For the 2-mile run, time was recorded; for both sit-ups and push-ups, repetitions completed in 2 minutes were recorded. Sit-ups were performed with legs bent at a 90° angle and the hands behind the head. Soldiers were asked for an individual best effort.

Medical Records Screening

In the Army, all visits to a medical treatment facility for medical care (exclusive of dental care) are recorded in the soldiers' medical treatment records. Injury data were collected by a complete review of the soldiers' medical records conducted for the 6-month period (October to March) before the briefing and the APFT. For each medical incident, four pieces of information were abstracted: diagnosis, body part, disposition, and days of limited duty (if any). A limited duty day was a 24-hour period in which the soldier was prohibited from performing all or part of his normal daily activities.

An injury was defined as any acute, overuse, or traumatic event transcribed in the medical record during the 6-month period. The first visit for a newly reported condition was the marker defining an injury case. Because a soldier could make more than one visit for a single injury, a further distinction was made between initial injury visits and follow-up visits. Follow-up visits were identified by specifications as such in the medical records or because multiple visits were made for the same type of injury to the same body part in a brief period of time.

Data Analysis

For each injury, the total number of initial injury visits, the total number of follow-up visits, and the number of limited duty days were tallied. Injuries were divided into two categories: (1) those that were musculoskeletal in nature and (2) all other injuries.

To examine the influence of differences in age, subjects were separated into three age groups: <20 years, 20 to 24 years, >24 years. The χ^2 statistic (2×3 analysis) was used to examine the hypothesis that there was no difference in injury frequency among the age groups. Cochran's test of linear trend[19] was used to examine the significance of the proportion of soldiers injured (percent) for successively higher age categories. A one-way analysis of variance (ANOVA) was used to test the hypothesis that there was no difference in the number of days of limited duty among the groups.

To examine associations between fitness and injuries, subjects were separated into quartiles for each of the three fitness measures and the cumulative incidence of soldiers with one or more musculoskeletal injuries were compared in each quartile. For each fitness measure, the χ^2 statistic (2×4 analysis) was used to test the hypothesis that there was no difference in injury occurrence among the different fitness levels. Cochran's test of linear trend was used to examine the significance of the proportion of soldiers injuries (percent) for successively higher fitness levels.

Results

Table 1 summarizes the injuries abstracted from the subjects' medical treatment records. One hundred fifty-one (51%) of the 298 soldiers experienced 212 injuries, for which they made 327 clinic visits during the six month period. The crude annualized injury rate (initial injuries) was 142 injuries per 100 soldiers (a soldier could have more than one injury). Musculoskeletal pain was the most frequent diagnosis, followed by strains, sprains, and cold-related injuries. Fractures accounted for the largest number of limited duty days, followed by sprains and cold-related injuries. With regard to disposition, 56% of the cases returned to full duty, 31% were placed on limited duty, and 1% (2 cases) were hospitalized. In 12% of the cases the disposition could not be determined.

Figure 1 shows the distribution (percent) of injuries by body part. The largest number of injuries involved the feet, followed by the ankles and knees. Lower extremity and low back injuries accounted for 65% of all injuries. The body part was not listed in the medical record in 7% of the injury cases.

Figure 2 shows the association between age and the cumulative incidence of injury. There was no difference in injury incidence among the three age groups for either all injuries (χ^2, $P = .15$) or the musculoskeletal injuries alone (χ^2, $P = .24$). However, the proportion of soldiers injured tended to decrease with older age categories for both all injuries (linear trend, $P = .05$) and musculoskeletal

TABLE 1
Injury Frequency and Limited Duty Days of Infantry Soldiers During a 6-mo Period

Injury	Injury Visit Frequency		Limited Duty Days	
	Initial Injury Visits (n)	Follow-Up Visits (n)	Total (n)	Days/ Initial Injury
Musculoskeletal injuries				
Musculoskeletal pain	42	26	118	2.8
Strains	29	14	86	3.0
Sprains	22	16	367	16.7
Traumatic injuries	14	4	106	7.6
Overuse injuries	12	1	28	2.3
Tendinitis	6	4	42	7.0
Fractures	5	18	516	103.2
Other	8	9	24	3.0
Other injuries				
Cold-related injuries	22	9	272	12.4
Contusions	19	7	139	7.3
Blisters	14	1	17	1.2
Abrasions/lacerations	12	4	18	1.5
Ingrown toenails	4	1	26	6.5
Other	3	2	5	1.7
Total	212	115	1764	

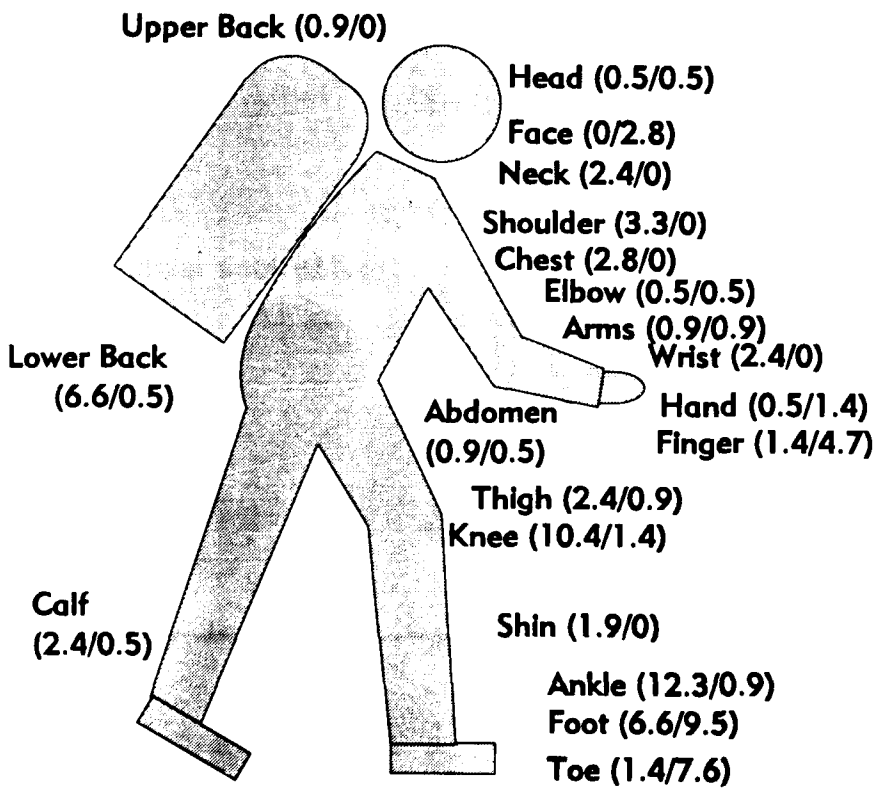

Fig. 1. Distribution of injuries by body part. Numbers refer to the percentage of injuries at each body part. The first number represents musculoskeletal injuries; the second number represents other injuries.

injuries (linear trend, $P = .09$). The number of days of limited duty did not differ among the three age groups for either all injuries (ANOVA, $P = .81$) or musculoskeletal injuries alone (ANOVA, $P = .62$).

Associations between physical fitness and the cumulative incidence of soldiers with musculoskeletal injuries are shown in Figs. 3 to 5. Soldiers ran the 2 miles in an average (±SD) 13.5 ± 1.2 minutes and performed 66 ± 10 sit-ups and 55 ± 12 push-ups. For the 2-mile run (Fig. 3), soldiers in the slowest quartile were 1.6 times more likely to have been injured than were subjects in the fastest quartile (χ^2, $P = .10$; linear trend, $P = .01$). For sit-ups (Fig. 4), soldiers in the quartile performing the lowest number of repetitions were 1.9 times more likely to have been injured than were subjects in the quartile performing the most repetitions (χ^2, $P = 0.01$; linear trend, $P = .002$). For push-ups (Fig. 5), differences in injury incidence among quartiles were not significant (χ^2, $P = .28$, linear trend, $P = .20$).

Discussion

When making direct comparisons of injury incidence among studies, differences in injury definition, methods of data collection (medical records, questionnaires, interview, etc) and differential access to medical care must be considered. Tomlinson et al[12] reported a crude annualized injury rate of 134 injuries per 100 infantry soldiers at a large Army post, a figure that agrees well with our study. Their definition of injury and methodology was similar to ours. Tomlinson et al[12] reported that the overall injury rate for the entire Army post (which included many sedentary occupations) was 81 injuries per 100 soldiers. Fleming[10] reported a lower injury rate in a combination of occupational activities (infantry, armor, artillery, and aviation), but he employed a more restrictive definition of injury.

Injury incidence reported for civilians participating in sports activities appears to be similar to those in this study. If the assumption is made that most sports seasons are 3 months long, the crude monthly sports injury

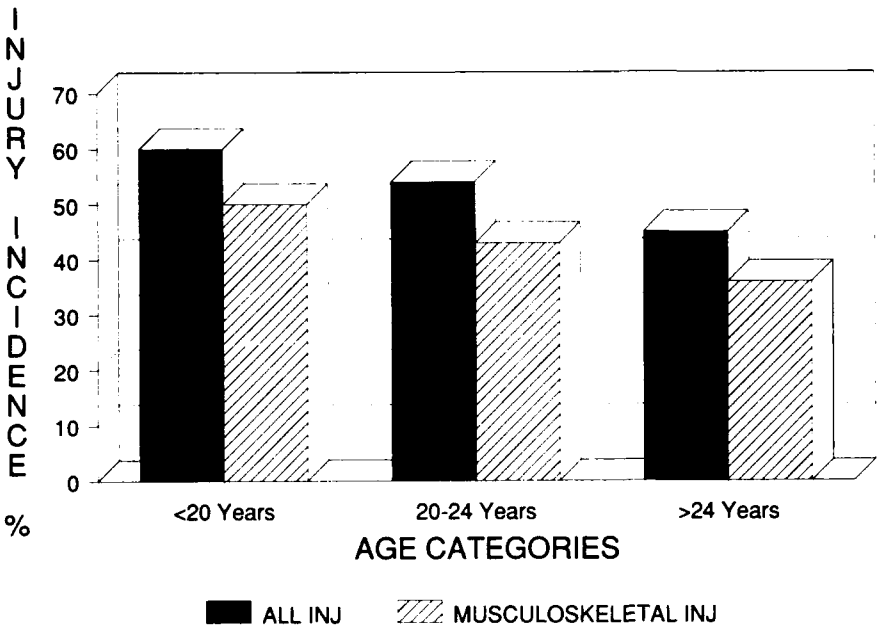

Fig. 2. Association of age with injuries (INJ).

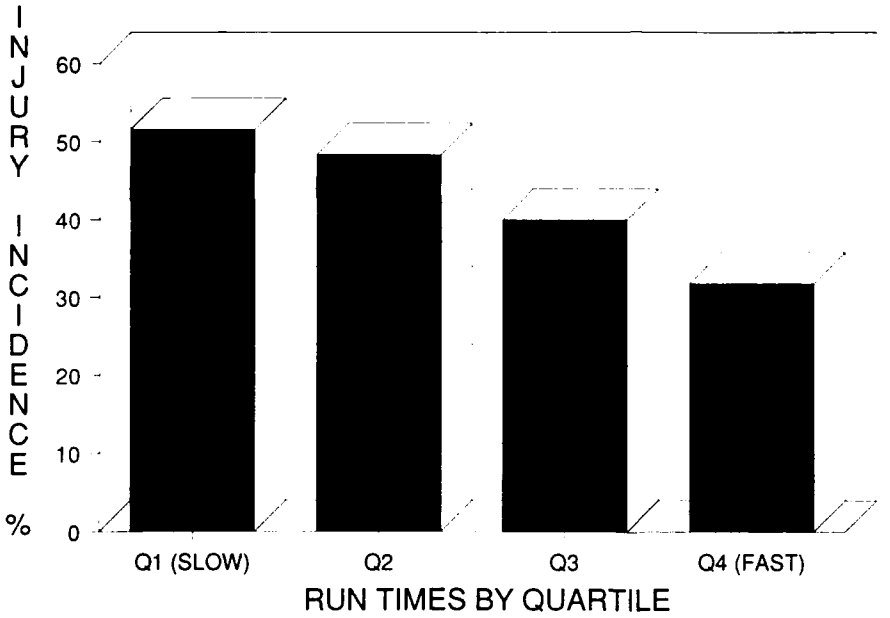

Fig. 3. Association of 2-mile run with musculoskeletal injuries.

rate is 15 injuries per 100 male athletes,[20] similar to the crude monthly rate of 12 injuries per 100 soldiers found here. On the other hand, the monthly injury rate in the general American population (which does not include the Armed Forces) is only 2 injuries per 100 men.[1,21] Differences in methods of collecting injury data could account for some of this discrepancy.

The greater level of physical activity may account for the higher injury rates in sporting and military populations when they are compared to other civilian populations. It has been consistently demonstrated in runners that as running mileage (exposure) increases, the likelihood of injury also increases.[15,22,23] In soldiers it is not possible to isolate exposure to a single factor. Infantry soldiers experience a wide range of potential injury-producing activities during the normal course of training.

We examined training schedules to determine the types of physical activity performed by the soldiers. No systematic assessment could be performed because some of the past schedules were missing and the four companies that made up the battalion performed different amounts and types of activities. However, from direct observation and available schedules, some generalizations were possible. About 3 times a week, in the early morning, physical training consisted of running, calisthenics and, on occasion, resistance (weight) training. After breakfast, a morning formation was conducted, after which soldiers either performed field exercises or attended classroom sessions. Field exercises were varied and consisted of such activities as land navigation, constructing defensive positions (foxholes, barricades, and mine fields), breaching obstacles, training with weapons, vehicle maintenance, and first aid. Subjects marched with heavy rucksacks to field training areas. In the winter months, snowshoeing and cross-country skiing replaced road marches. Subjects also engaged in sports activities (softball, soccer, etc). At least two major field training exercises, in which the soldiers spent up to 1 week living in the field, occurred during the 6-month period.

Age and Injuries

In this study, the proportion of soldiers injured tended to decrease with age. This is in consonance with national statistics that show annual injury rates of 33 and 25 injuries per 100 men for 15 to 24 and 25 to 44 years old, respectively.[1] Tomlinson et al[12] also demonstrated lower injury rates for older soldiers in a wide variety of military occupations.

On the other hand, Jones et al[6] showed that in basic training, older soldiers suffered more injuries than younger soldiers. In basic training, all soldiers perform essentially the same type and amount of physical activity. In other military populations, older soldiers are more likely to be of higher rank and to be in staff or supervisory positions; they may be more sedentary and less exposed to physical hazards. Further efforts will be required to par-

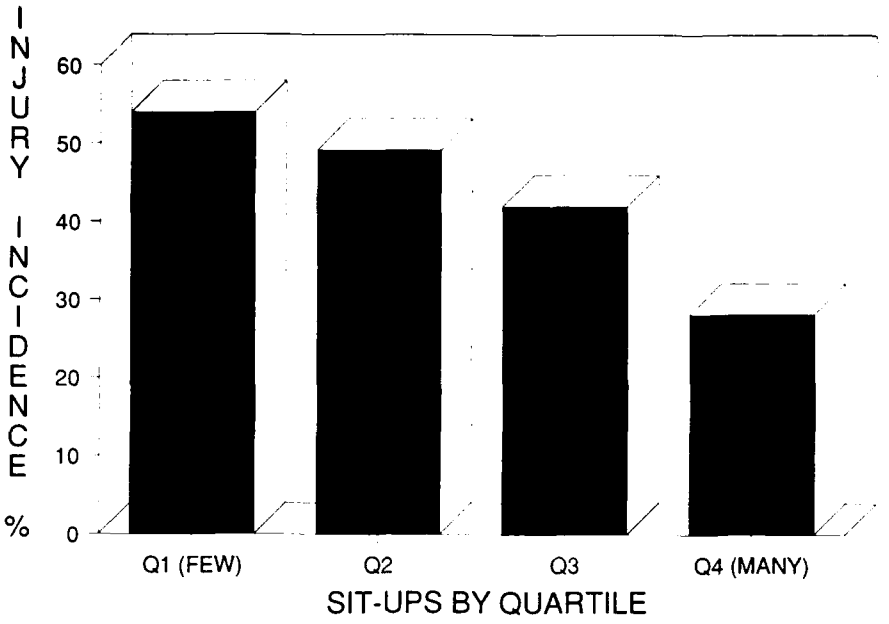

Fig. 4. Association of sit-ups with musculoskeletal injuries.

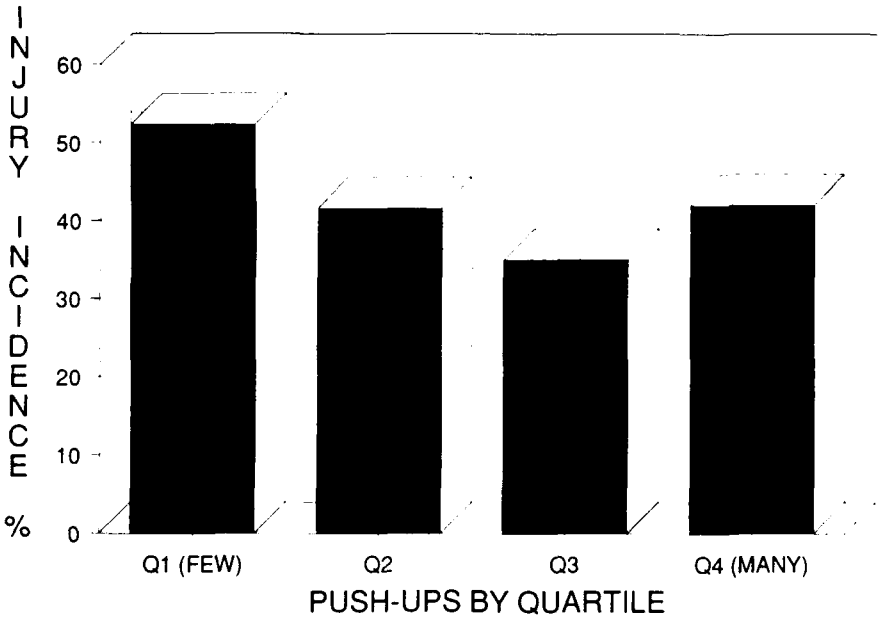

Fig. 5. Association of push-ups with musculoskeletal injuries.

tition out factors relating age to injuries in the military.

Fitness and Injuries

In this study, musculoskeletal injuries occurring over a 6-month period were associated with lower aerobic fitness and lower muscle strength fitness. However, because the physical fitness measures were obtained after the medical records screening, it is not possible to determine whether the association indicates that injuries cause lower fitness levels or the opposite, that a lower fitness level predisposes to injury. We suspect the latter because several prospective cohort studies of US Army basic trainees[5-7] show that those trainees with low fitness levels are more likely to sustain injuries.

Prospective studies of civilian populations involved in recreational activities suggest that both higher aerobic fitness and higher muscle strength fitness[13,14] are associated with higher injury incidence. Higher physical activity of appropriate frequency, intensity, and duration can increase aerobic fitness,[24] and this may confound the association between fitness and injuries.[14] On the other hand, in US Army basic training, all trainees perform essentially the same level of physical activity regardless of fitness level. This is probably why military studies have been able to demonstrate an association between lower fitness level and higher risk of injury.[6] To a great extent, younger infantry populations also perform relatively homogenous physical activities. Prospective studies should be conducted to investigate more fully the associations between fitness and injuries in infantry soldiers.

Conclusions

It has been shown that those in military service have favorable health habits that include high levels of physical activity.[25] Although the benefits of physical activity are well documented,[26] there are potential hazards. This study demonstrates a high incidence of injuries in physically active soldiers serving in an infantry unit. Injuries over a 6-month period resulted in the equivalent of 4.8 man-years of limited duty. The proportion of soldiers injured decreased with age, and the increased incidence of injuries was associated with lower levels of aerobic and muscle strength fitness. Although most of the injuries caused only temporary disability, they could be a threat to the effectiveness of infantry units that must operate as a team.

Because of the implications for injury prevention, prospective studies are needed to clarify the association between injuries, age, and fitness in this active occupational group. Systematic identification of high-risk exposures for specific injuries would be useful and could help with the development of countermeasures.[27]

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