Injuries in Australian Army Recruits. Part I: Decreased Incidence and Severity of Injury Seen with Reduced Running Distance

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Three hundred fifty male recruits were randomly allocated to either the standard recruit training program (N = 180) or substituted a weighted march activity for all running periods in the physical training program (N = 170). There were no other differences in the formal training program. The incidence of injury was 37.6 and 46.6% in the walk and run groups, respectively. The rate of injury was 52.9/100 recruits in the walk group and 61.7/100 in the run group. The exposure incidence was 12.8/1,000 hours of physical training in the walk group and 14.9/1,000 hours in the run group. There was no statistically significantly difference in the total number of injured recruits in the two groups (64 vs. 85, χ² = 2.90, P = 0.09, relative risk [RR] = 1.24). There were, however, significantly more lower-limb (43 vs. 75, χ² = 9.77, P = 0.0018, RR = 1.65) and knee injuries (15 vs. 35, χ² = 6.54, P = 0.011, RR = 2.14) in the Run group. Lower-limb injuries constituted 79.8% of all Run injuries and 61.1% of all Walk injuries. Injuries in the Run group produced more morbidity, with nearly double the number of days of restriction, hospitalization, and not fit for duty. Standardized morbidity rates showed an average of 5.4 days of restriction per injury in the Run group and 3.96 days of restriction per injury in the Walk group. Reduction of running distance in the physical training program resulted in significant reductions in both the incidence of lower-limb injury and the overall severity of injury.

Introduction

Lower-limb injuries have been frequently reported in populations of civilian runners and military recruits. Running has been suggested as a major cause of lower-limb injuries in military recruits. van Mechelen, in a review of running injury epidemiology, noted that the incidence of running injuries ranged from 24 to 77%, but in studies with more than 500 subjects the annual incidence varied from 37 to 56%. Seventy to 80% of all running injuries were at or below the knee, with the knee itself involved in 25 to 40% of cases.

Jones et al., in a 12-week study of two U.S. Army infantry companies, reported an incidence of injury of 45.9%, with a cumulative incidence of lower-limb injury of 37%. Bensal and Kish reported an overall injury rate of 37% in U.S. Marines, with the rate of lower-limb injury being 25%.

Jordaan and Schwellnus found an incidence of 1.8 injuries/1,000 physical training hours; however, this included field training, which constituted nearly two-thirds of the total physical training exposure. This compares with rates of 8.1/1,000 hours in another South African study and 10.1/1,000 hours reported in recruits in New Zealand.

This study hypothesized that the substitution of running with an alternative aerobic activity (weighted-pack marching) would result in a significant reduction in the incidence and severity of lower-limb injuries.

Materials and Methods

Study Design

This study was a randomized, controlled trial comparing a group of recruits who underwent a standard Australian Army physical training program with a group who substituted a "weight-load walking" activity in all programmed running periods. There were no other formal differences in the training program.

The groups were followed prospectively for the duration of a 12-week recruit course. Data on the nature, incidence, cause, and associated morbidity of injury were collected, and various physiological parameters were also measured.

The recruits were given an information sheet detailing the aims of the study, and this was reinforced with a verbal briefing. All gave written consent for participation.

Sample Selection

Recruits were allocated into platoons of approximately 45 by staff at the 1st Recruit Training Battalion (1 RTB), Wagga Wagga, New South Wales, during March and April 1989.

Recruiting units faxed the names of recruits who were scheduled to arrive later that day. The training clerk allotted names to a platoon on an "as-received basis," i.e., the names of recruits were entered onto platoon nominal rolls as the faxes were received. Once a platoon quota was filled, the second platoon was raised. The clerk allocating recruits was thus blinded to any personal characteristics of the recruits. The recruits were drawn from all over Australia and ranged in age from 17 to 31 years, with an average age of 19.1 years. They were all male.

Two paired platoon groups were enrolled during a given week, and a platoon was randomly assigned to be either a Walk or a Run group by being drawn from a hat by the author, who was blind to the composition of the groups. Four pairs of platoons were enrolled over 4 consecutive weeks. There were 170 subjects in the Walk group and 180 in the Run group.

Training Program

The standard physical training program is detailed in Figure 1. This program was employed by all platoons undergoing training at 1 RTB during 1989.

There was 20 km of marching in running shoes and webbing, because it was felt that this would provide a transition to marching in boots. It was noted that many platoon commanders con-
Injuries in Australian Army Recruits

considered the route marches as a race, and it was anecdotally reported that up to half of a programmed march would be run. This was not specified in the training program, and there was no intervention because this was allegedly normal practice in the control group.

There were 62 separate 40-minute programmed periods of physical training, resulting in 41.3 hours of physical training per recruit over the 12-week course. This equates to 7,440 hours of exposure in the Run group and 7,026.6 hours in the Walk group. This figure does not include field training.

The Weight-Load Walking Program

The Walk group substituted a walk activity wherever a run was scheduled in the physical training program. During the first 3 weeks, an initial weight of 16.2 kg was carried. This consisted of rifle, basic webbing, full water bottles, and backpack with blanket and sleeping bag. From week 5, additional weight in the form of house bricks weighing 2.6 kg was added each week.

The speed of marching was gradually increased over the first 3 weeks from 5.0 to 6.0 km/hour and was then increased to a maximum of 7.5 km/hour.

The Walk group performed two 5-km runs for testing purposes in weeks 3 and 6 and were specifically forbidden to run during route marches. This resulted in an officially programmed difference in running distance of 16.5 km between the two groups.

Injury Data

Injury data were collected from attendance records maintained by the treating medical facility (regimental aid post) as well as the nearby military hospital. Every attendance at the regimental aid post was recorded on the standard medical consultation form (PM 60). Information about the location, nature, cause, and morbidity (restriction/not fit for duty) of each injury was obtained. Hospital morbidity data were obtained from patient discharge summaries.

Statistical Methods

Chi-square ($\chi^2$) analysis was performed on the injury data to determine any significant differences between the two groups. Significance was set at the 0.05 level. All statistical analysis was performed using the Statview 512 program on the Apple Macintosh computer.

Results

The mean ages for the Walk and Run groups were 19.0 (95% confidence interval [CI] 18.6-19.4) and 19.2 years (95% CI 18.7-19.7), respectively. The mean height of the Walk and Run groups was 176.5 (95% CI 175.6-177.5) and 176.9 cm (95% CI 175.9-177.9), respectively. There were no significant differences between the two groups.

Number of Recorded Injuries

Table I summarizes the injury data. There were 64 injured Walkers and 85 injured Runners, accounting for 90 and 109 recorded injuries, respectively. The rate of recorded injury was higher in the Run group (60.5/100 vs. 52.9/100), and the percentage of recruits reporting an injury was 37.6 and 46.6% in the Walk and Run groups, respectively. There was no statistically significant difference in the total number of injured recruits between the two groups.

The Run group (41.7%) had significantly more recruits with lower-limb and knee injuries than the Walk group (25.3%). Lower-limb injuries constituted 62.3% and 79.8% of all reported injuries in the Walk and Run groups, respectively.

The relative risk of all injury in the Run group compared with the Walk group was 1.24. The relative risks for lower-limb and knee injury were 1.65 and 2.14, respectively.

| TABLE I | RAW INJURY DATA FOR THE WALK AND RUN GROUPS |
|---|---|---|
| Walk | Run | $\chi^2$ | p | RR, relative risk |
| Number Injured | 64 | 85 | 2.90 | 0.09 | 1.24 (0.98-1.61) |
| Number of Injuries | 90 | 111 | 9.77 | 0.0018 | 1.65 (1.21-2.25) |
| Rate of Injury (/100 recruits) | 52.9 | 60.5 | 6.54 | 0.011 | 2.14 (1.21-3.79) |
| Rate of Injury (/1,000 hours of physical training) | 12.8 | 14.9 | |
| Number of lower limbs injured | 43/170 (25.3%) | 75/180 (41.7%) | 9.77 | 0.0018 | 1.65 (1.21-2.25) |
| Lower-limb injuries (excluding blisters) | 56/90 (62.3%) | 87/109 (79.8%) | 6.54 | 0.011 | 2.14 (1.21-3.79) |
| Number of knee injuries | 15/170 (8.8%) | 34/180 (18.8%) | |

RR, relative risk.
Causes of Failure to Complete Training

Table II lists the reasons given for various recruits failing to complete training within the allotted 12 weeks. The wastage rates (all causes) were 23.5 and 19.4% for the Walk and Run groups, respectively.

There were more medical discharges in the Run group, but this difference was not statistically significant ($\chi^2 = 3.10, p = 0.07$). The rate of medical discharge was higher in the Run group (8.9%) than in the Walk group (5.9%). The number of administrative discharges and backsquadding was higher in the Walk group, and the reasons for this were not clear. The study was designed to capture medical data, and causes for administrative discharge were not collected.

Timing of Injuries

Figure 2 shows the frequency of recorded injury at each week of the 12-week training program. It shows that the peak period for injury was in the first 2 weeks in both groups. In the Run group, there was another peak in weeks 5 to 7, and this is demonstrated more clearly in Figure 3. There were 19 more injuries in the Run group during the middle 4 weeks of the training program, and this difference accounts for nearly the total difference in injury between the two groups.

This middle 4-week period corresponded to a build-up in run training in preparation for the basic fitness assessment, held in week 6, which required the successful completion of a 5-km run. It was also the period when there was an increasing component of route marching.

Morbidity Associated with Each Group

Table III demonstrates major differences in the morbidity associated with injury in the two groups. The Run group had nearly twice as many days of restricted duty, sick leave, and hospital bed days as the Walk group, and an average of 1.44 more days of restriction per injury than the Walk group.

Table IV shows the demand placed on medical resources. There was both an absolute and a relative increase in the number of medical officer visits per injured recruit in the Run group. The rate of medical assistant visits was the same.

Discussion

Reducing running distance in the Walk group led to a significant reduction in the number of lower-limb injuries and the morbidity associated with injury.

Although there was no statistically significant difference in the number of injured recruits between the two groups, there were significant increases in the number of lower-limb and knee injuries in the Run group, with relative risks of 1.5 and 2.34, respectively.

The raw incidence values for injury of 37.6 and 46.6% are in accordance with those from other studies. Jordaan and Schwellnus reported an overall injury incidence of 31% during a 9-week course, with 85% of these injuries being to the lower limb. Jones et al. reported a rate of 45.9% in infantry trainees, with lower-limb injuries accounting for 80%. The relative contribution of lower-limb injuries in the Run group (79.8%) is similar to that found in these studies, whereas the contribution of lower-limb injuries in the Walk group was significantly less (61.1%).

Using an exposure measure to express incidence, the Walk group had a rate of 12.8 injuries/1,000 hours of physical training and the Run group had a rate of 14.9/1,000. These rates were higher than those reported by Gordon et al. in South African recruits (8/1,000) and Stacey and Hungerford in New Zealand recruits (10/1,000), but much higher than those reported by Jordaan and Schwellnus (1/1,000), who included field training in their exposure.

This decrease in lower-limb injury was achieved with no loss of military effectiveness. The Walk group passed all physical fitness terminal objectives (including a 5-km run test), and subjective observers could not distinguish their performance on military tasks from that of the Run group.

Running distance is a consistently identified risk factor for injury in civilian runners. A number of studies have found a linear relationship between weekly running distance and the incidence of injury, i.e., the greater the distance run, the greater the number of injuries.

Jones supported this finding in a study of two U.S. Army infantry companies, one classed as "high-mileage" (ran 130 miles/marched 68 miles) and the other as "low-mileage" (ran 60 miles/marched 117 miles). The low-mileage company had an incidence of injury of 32.5%, compared with an incidence of 41.8% in the high-mileage company (relative risk = 1.29, 95% CI 0.96–1.73).

Injury to the knee is particularly associated with running. The relative risk for knee injury in the Run group was 2.14, with the incidence of knee injury being 18.8% in the Run group and 8.8% in the Walk group. In civilian runners, injuries involve the knee in 25 to 40% of cases. Studies in military trainees show similar rates of 21%, 34%, 10% and 40%.

In the training program, there was only a 16.5-km difference in the formal running distance between the two groups. However, it was common practice for normal platoons to run up to 2 km in boots in regular cycles during route marches. Therefore, many platoons would run 2 km, walk 2 km, and then run 2 km, repeating this for the duration of the allotted distance. The Walk platoons were forbidden to run during any part of the route-march phase.

However, despite this probable increase in running distance, the Run platoons remain a valid control group. The exposure variable was a small, controlled volume of 10 km of running, and this was compared with a greater running distance regime. It was unfortunate that the true exposure varied somewhat in the Run group, but this was beyond the control of the experimental design (or the investigator). The true difference in running distance was likely to have been on the order of 40 km.

This is still a relatively small difference in exposure and suggests that running distance is a potent contributor to lower-limb injury.
Injuries in Australian Army Recruits

Injuries in Australian Army Recruits

The majority of injuries occurred in the first 2 weeks of training in both groups, and this was similar to the experience of Jordaan and Schwellnus9 and Ross and Woodward.15 This suggests inadequate progression of activity in the early stages of training and probably represents what Lysholm and Wiklander have termed a training error, i.e., going too fast, too long, or too often. Re-evaluation of the physical training progression has taken place at 1 RTB.

The major difference in injuries between the groups occurred during the middle phase of training, between weeks 5 and 8.

This paradoxically was a time of predominantly march training, but for the reasons stated above, it was likely that a significant amount of running in boots was done. It is this running in boots that is the likely cause of the increase in injury seen in the Run group. The relatively low number of injuries in the Walk group suggests that simple marching caused fewer injuries, despite the large distances covered (53 km).

The overall wastage rates were 23.5 and 19.4% in the Walk and Run groups, respectively. There were more medical discharges in the Run group (16 vs. 10), but this was not statistically significant.

There were more administrative discharges in the Walk group, but again this was not statistically significant (p = 0.078). Administrative discharge included those who requested discharge, those whose parents withdrew consent, those who failed to achieve training standards, and those who were discharged as psychologically unsuitable. Why there was such a high preponderance of administrative loss in the Walk group is not known because the study was geared to capturing data on medical discharges.

The morbidity associated with injury in the Run group was much greater than that in the Walk group, with nearly double the total number of days of sick leave, hospitalization, and restricted duty. When standardized by the number of injuries, the Run group had 5.4 days of restriction per injury compared with the Walk group with 3.96, with more pronounced differences for bed days and sick leave. This suggests that injuries caused by run training were more severe than those caused by marching.

| TABLE IV |
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| REGIMENTAL AID POST VISITS FOR THE WALK AND RUN GROUPS |

| Medical assistant (MA) | Walk | Run |
|——|——|——|
| Medical officer (MO) | 44 | 74 |
| Total | 134 | 194 |

| Medical assistant (MA) visits per injured recruit | 1.41 |
| Medical officer (MO) visits per injured recruit | 0.69 |
| Total visits per injured recruit | 2.09 |

| TABLE III |
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| MORBIDITY ASSOCIATED WITH THE WALK AND RUN GROUPS |

| Restricted duty days | Walk | Run |
|——|——|——|
| Not fit for duty days | 356 | 600 |
| Hospital bed days | 44 | 87 |
| Restricted duty (days/injury) | 3.96 | 5.40 |
| Not fit for duty (days/injury) | 0.49 | 0.78 |
| Hospital bed days (days/injury) | 0.47 | 0.74 |

Fig. 2. Number of reported injuries by week of training.

Fig. 3. Number of recorded injuries at each stage of training.
The burden placed on the medical services was illustrated by the number of medical center visits within the two groups: 194 in the Run group and 134 in the Walk group. Although medical assistant visits were similar at 1.41 visits per injury, there was a disproportionate increase in the number of medical officer visits seen in the Run group. This, again, is a probable reflection of the increased severity of injury seen in the Run group.

An epidemiological study of injuries in the Australian Army found that lower-limb injuries constituted 40% of all reported injuries but were responsible for 50% of all bed days, 48% of all sick leave, and 51% of all restricted duty. Knee injuries had disproportionately severe morbidity, representing 21.5% of all reported injury but being responsible for 35% of bed days, 54% of sick leave, and 32% of restricted duty.

Marti et al. found that 5% of civilian running injuries produced a mean work absence of 10.1 days, and 44% of runners had an injury that kept them from training for a mean duration of 4.8 weeks.

Running produces a ground reaction force of between two and three times body weight on impact. Walking produces a force equal to body weight. These impact forces are absorbed by the soft tissues of the lower limb, primarily muscle. In the normal leg, the arch structure of the foot and the musculature of the calf act as shock absorbers.

Fatigued muscle in rats has been shown to absorb less energy than nonfatigued muscle. Muscles are frequently injured under conditions of high-intensity eccentric loading, where they are required to absorb energy and provide control and regulation of limb movement. In rats, fatigued muscle was able to absorb less energy before reaching the degree of stretch at which injury occurred.

Muscle fatigue increases with increasing duration of activity. With increasing running distance, it seems reasonable to postulate that increasing fatigue and consequent decreases in energy absorption will result in increasing amounts of force being absorbed by the surrounding soft tissues and joints. Forces exceeding the tensile strength of the soft or bony tissues are likely to result in tissue damage and injury.

With running in boots, much of the natural shock-absorbing mechanism of the foot is overridden by the rigid boot. Therefore, there is much greater shock transmission to the knee and surrounding soft tissues. In addition, running in the relatively heavy boot is likely to speed the onset of fatigue and decrease energy absorption.

The major difference between civilian and military runners is compulsion. Soldiers must run as part of their occupational requirement to be fit and pass running tests of various distances. Civilian runners who experience pain often stop and seek early treatment. Military runners, especially trainees, will "run through the pain" and often conceal injuries for fear of backsquadding, which will delay the completion of their course. They are often the recipients of advice from enthusiastic physical training instructors, who exhort recruits to keep going with phrases such as "pain is weakness leaving the body" and "no pain, no gain."

Given that continuous distance running appears to be a potent cause of injury, the question arises, why do it? The obvious answer is to pass the test. But this may be a case of the tail wagging the dog. It is possible to achieve good performance on run-based tests without repetitive cycles of distance running. Interval training has been an accepted method of aerobic training since the 1930s. Short to moderate periods of work are alternated with short to moderate periods of rest, with a typical session involving sets of 400- and 800-m runs.

From an occupational perspective, a soldier has little need to run 3 to 5 km distances. Most combat activities involve short sprints or long marches. The current emphasis on middle-distance running must be questioned. Interval training may be a more effective way of achieving necessary aerobic fitness without the current price of high rates of injury.

The findings of this study support the hypothesis that the substitution of running with an alternative aerobic activity will result in a decrease in injuries. The decrease in lower-limb and, in particular, knee injuries was pronounced. Given that the Walk group successfully completed all terminal training objectives of the recruit course, it is proposed that reductions in running distance could be introduced into recruit training programs with no loss of military capability and a likely reduction in lower-limb injury.

References