

Prevalence and incidence of lower extremity injuries in male marathon runners

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The aim of this study is to describe the prevalence and incidence of lower extremity injuries occurring before and during the Rotterdam marathon, and to evaluate the impact of the injuries. A cohort study was compiled of recreational male participants in the 2005 Rotterdam marathon. Demographic data and information on previous injuries were obtained from participants using a baseline questionnaire. Information on injuries sustained shortly before or during the marathon was obtained from a post-race questionnaire. Seven hundred and twenty-five (48.3%) participants returned the baseline questionnaire. The 1-year prevalence of running injuries was 54.8%. In the post-race question-

naire, 15.6% of all respondents reported at least one new lower extremity injury in the month preceding the Rotterdam marathon. The incidence of lower extremity injuries occurring during the marathon was 18.2%; most of these injuries occurred in the calf, knee and thigh. Immediately after the marathon the median score of pain intensity at rest was 2 points vs 4.5 points during physical exercise. Hence we can conclude that running injuries are very common among recreational male marathon runners. However, the pain severity and consequences for work and daily activities seem to be relatively low 1 week after the marathon.

The health benefits of regular exercise have been documented extensively (Siscovick et al., 1985; Powell et al., 1987; Sandvik et al., 1993; Melzer et al., 2004). Long-distance running is a popular form of physical exercise that is practiced by many persons. More and more people are taking part in major international running events such as the city marathons in New York, Los Angeles, Rotterdam, or London (Van Bottenburg, 2006). Besides the positive health effects of running, and especially marathon running, may also cause injuries, especially to the lower extremities (Maughan & Miller, 1983; Kretsch et al., 1984; Lysholm & Wiklander, 1987; Satterthwaite et al., 1996). Various studies have reported annual rates of lower extremity injuries for runners ranging from 19% to 75% (Maughan & Miller, 1983; Jakobsen et al., 1989; Macera et al., 1989; Bennell et al., 1996; Wen et al., 1998; Taunton et al., 2003; Lun et al., 2004). The most predominant site of lower extremity injuries is the knee, of which the reported location-specific incidence ranges from 9% to 50% (Satterthwaite et al., 1996; Steinacker et al., 2001).

It is probable that injuries affecting the lower extremities are caused not only by participation in the event but also by the necessarily long training sessions (Maughan & Miller, 1983; Van Mechelen,

1992). Previous marathon studies have reported the high incidence of injuries during or shortly after running the marathon (Nicholl & Williams, 1982, 1983; Maughan & Miller, 1983; Kretsch et al., 1984; Macera et al., 1991; Satterthwaite et al., 1996). However, there is no agreement in these studies regarding the incidence of running injuries of marathon runners. Most of these studies used different definitions of injuries and some, for example, also included blisters as a running injury.

Only a few studies have investigated the number of injuries associated with training before a marathon event, reporting prevalence rates of 29–58% (Maughan & Miller, 1983; Kretsch et al., 1984; Macera et al., 1989, 1991). Moreover, they have methodological shortcomings, e.g. there is no clear definition of a running injury, demographic characteristics were not reported, and/or a retrospective study design was used. Thus, few data are available on the prevalence and incidence of injuries associated with training for a marathon, or during a marathon. Therefore, the aim of this prospective study was to describe the prevalence and incidence of lower extremity injuries occurring before and during the Rotterdam marathon, and to evaluate the impact of the injuries.

Methods

Study participants

The Rotterdam marathon is a run over a standard-length course (42.2 km) through the city of Rotterdam. The Rotterdam marathon 2005 began at 11:00 hours on Sunday, April 10. Out of the 6000 recreational male athletes who signed in for the Rotterdam marathon, a random sample of 1500 athletes was made. One month before the start of the Rotterdam marathon a baseline questionnaire was sent by a mail order firm to the 1500 randomly selected participants. These were asked to return the questionnaire by post before the marathon took place. Runners were included in the study if they met the following criteria: (1) they had to be a male resident of the Netherlands; (2) they were recreational/amateur runners; and (3) they returned the baseline questionnaire before running the 2005 Rotterdam marathon. Immediately after the Rotterdam marathon, a post-race questionnaire was posted to all included male runners. Those not returning the second questionnaire were posted a reminder and residual non-responders were later contacted by telephone and requested to return the completed questionnaire.

Recreational runners were runners who signed in for the Rotterdam marathon and were not competitive with the professional runners in the Rotterdam marathon race.

Questionnaires

Information about lower extremity injuries in the previous 12 months and information about injuries at the moment of completing the questionnaire was obtained from the baseline questionnaire. Participants were also asked to indicate the site of the injury. Running activity was measured in terms of the number of kilometers run per week (average from preceding 3-month total), number of hours run per week (average from preceding 3-month total), frequency (average from preceding 3-month total), total running kilometers in the previous 12 months and years of running experience.

The second, post-race questionnaire, obtained information regarding new injuries occurred during the month before the Rotterdam marathon and any injuries incurred during the marathon. These injuries were distinct from the injuries reported in the first questionnaire. An 11-point numerical rating scale (score range 0–10) measured the pain intensity of the lower extremity injuries.

The questionnaire was developed by the investigators and it was pilot tested on a group of runners during the half marathon, 6 months before the start of the marathon. The main outcome measure for this study was a self-reported running injury. The injury definition was elaborated on the injury definition of Macera et al. (1989). A running injury was defined as "An injury to muscles, joints, tendons, and/or bones of the lower extremities (hip, groin, thigh, knee, lower leg, ankle, foot, toe) that the participant attributed to running." The problem had to be severe enough to cause a reduction in distance, speed, duration, or frequency of running.

Statistical analysis

Descriptive statistics were used for baseline characteristics. The chi-squared test was used to compare baseline characteristics, the proportions of injured runners who started or did not start the race and to compare the proportion of injured runners who finished or did not finish the race. SPSS (version 11) was used for the analyses.

Results

Baseline characteristics

Of the 1500 selected runners, 726 replied to the baseline questionnaire. One female runner returned the questionnaire because she bought the start package, including the start number and questionnaire, from a registered male and was for this reason excluded. The baseline characteristics of the 725 males are represented in Table 1.

The average age of the runners was 43.7 (SD 9.6) years, which was representative for the entire male event population (42.8 ± 9.3 years). The average weekly running distance in the 3-month period preceding the baseline questionnaire was 50.2 (± 18.4) km. On average, respondents ran 1845 km/year. More than half (54.8%) of the runners suffered at least one running injury during the year preceding the baseline questionnaire. Most of these lower extremity injuries occurred during training sessions (79.6%). The number of injuries per 1000 h of running was 3.2; the location of these injuries are given in Table 2.

The most common site of lower extremity injury was the knee (30.7% of the total injuries) followed by the calf (23.2%) and the foot (14.6%). At the time of the baseline measurement, 195 (26.9%) runners reported one or more current lower extremity injury.

Incidence of injuries

Of the 725 male runners who returned the baseline questionnaire, 694 runners (95.7%) returned the post-race questionnaire. A comparison of age, BMI, running experience, weekly training distance, weekly training hours, and previous injuries of the runners who completed both questionnaires, compared with who did not, showed no significant differences ($P > 0.05$).

Of the 694 runners, 46 (6.6%) did not start, and the outcome of one runner is unknown because this runner did not completely fill in the post-race questionnaire. Of those who did not start, 30 (65.2%) did

Table 1. Characteristics of participants ($n = 725$) at baseline

Characteristic	Mean (SD)
Age (year)	43.7 (± 9.6)
Height (cm)	182.1 (± 6.7)
Weight (kg)	78.2 (± 8.9)
BMI (kg/m^2)	23.6 (± 2.1)
Running experience (years)	10.7 (± 8.9)
Running patterns for preceding 3 months	
Weekly distance (km)	50.2 (± 18.4)
Weekly training (h)	5.6 (± 2.9)
Frequency (times per week)	3.6 (± 1.1)
Yearly kilometres	1845.1 (± 981.7)

BMI, body mass index.

Table 2. Localisation of running injuries

Location	Previous year	Complaints at baseline
Total	397 (100%)	195 (100%)
Hip	39 (9.8%)	13 (6.1%)
Groin	32 (8.1%)	14 (6.6%)
Thigh	49 (12.3%)	27 (13.8%)
Knee	122 (30.7%)	52 (26.7%)
Shin	50 (12.6%)	23 (11.8%)
Calf	92 (23.2%)	28 (14.4%)
Achilles' tendon	54 (13.6%)	15 (7.7%)
Ankle	33 (8.3%)	14 (7.2%)
Foot	58 (14.6%)	32 (16.4%)
Toes	21 (5.3%)	10 (5.1%)

not because of an injury. Of the 647 runners who started the race, 612 (94.6%) finished, and 35 (5.4%) did not finish. Of the 35 unfinished runners, 18 (51.4%) had an injury, seven (20%) were sick, and 10 (28.6%) had other reasons for not finishing.

Of the 397 runners who reported a running injury in the previous 12 months, 8.6% did not start while of the 328 runners who did not report a running injury 3.7% did not start ($P = 0.06$). In the post-race questionnaire, 15.6% ($n = 108$) of all respondents reported at least one new lower extremity injury in the month preceding the Rotterdam marathon. Of those runners who reported a new injury in the month preceding the marathon, 15 (13.9%) did not start, and seven (6.5%) started the marathon but did not finish. Runners who were injured in the month before the start were not at higher risk for not starting the race ($P = 0.82$) and not finishing the race ($P = 0.47$). Of the runners who had a running injury during the marathon race, 12.7% did not finish the race. This was significantly higher ($P < 0.001$) than those who were not injured (3.8%). The sites of these new lower extremity injuries are given in Table 3. The most frequent site was the knee (29.6%), followed by the calf (20.4%), and the foot (13.9%).

The incidence of lower extremity injuries in all started runners occurring during the Rotterdam marathon was 18.2% ($n = 118$); the site of these lower extremity injuries is given in Table 3. The most frequent site was the calf (33.9%), followed by the knee (27.1%), and the thigh (17.8%). In total, 197 (28.4%) runners incurred at least one running injury in preparation for or during the Rotterdam marathon.

Of all started runners, 13.6% ($n = 88$) had physical health problems other than in the lower extremities during the marathon. Most common cited problems were stomach-intestinal tract 33 (34.0%), locomotor apparatus (arms, neck, shoulder and back) 30 (30.9%) and the skin 10 (10.3%).

Table 3. Incidence of running injuries sustained before or during the Rotterdam marathon ($n = 694$)

Location	One month before marathon	Sustained in the marathon
Total	108 (100%)	118 (100%)
Hip	4 (3.7%)	8 (6.8%)
Groin	6 (5.6%)	1 (0.8%)
Thigh	11 (10.2%)	21 (17.8%)
Knee	32 (29.6%)	32 (27.1%)
Shin	3 (2.8%)	2 (1.7%)
Calf	22 (20.4%)	40 (33.9%)
Achilles' tendon	8 (7.4%)	9 (7.6%)
Ankle	10 (9.3%)	5 (4.2%)
Foot	15 (13.9%)	16 (13.6%)
Toes	1 (0.9%)	16 (13.6%)

Impact of injuries

The pain intensity of injured runners in rest immediately after the marathon ranged from 0 to 9 on an 11-point scale. The median score was 2 and the interquartile range (IQR) was 3. For pain intensity during physical exercise the median score was 4.5 (range 0–10; IQR 4).

Of all injured runners ($n = 118$) in the Rotterdam marathon, 86.4% were able to perform all their work tasks within 1 week after the marathon. Also 88.1% of all injured runners were able to carry out their usual activities of daily living (ADL) within 1 week. Sports and leisure activities could be carried out within 1 week by 53.4% of the injured runners.

Discussion

The health benefits of running are well known. Running is widely perceived to be beneficial to the cardiovascular system (Powell et al., 1987) and to reduce the risk of mortality (Blair et al., 1989). In addition, running has a positive effect on self-experienced physical fitness (Dyer & Crouch, 1988). In our study, 54.8% of the participants in a popular running event had sustained one or more running injuries during the year preceding the race. At the moment of filling in the first questionnaire, still 26.9% of the runners experienced a running injury. During or immediately after the marathon, 18.2% of the started runners reported at least one new running-related injury to the lower extremities.

During the 12 months preceding the Rotterdam marathon, 54.8% of the respondents sustained at least one running injury to the lower extremities that was severe enough to reduce distance, speed, duration or frequency of running. This result is in line with the study of Maughan and Miller (1983) who found a prevalence rate of running injuries of 58% preceding the marathon. However, Kretsch et al.

(1984) found that only 29% of the subjects reported some medical or physical symptoms, which occurred as a result of their training. This low prevalence may be partly due to methodological differences between the studies. Kretsch et al. (1984) asked patients to record serious medical and physical problems, whereas our study reported lower extremity injuries, which had to be severe enough to cause a reduction in distance, speed, duration or frequency of running.

The incidence of injuries during the Rotterdam marathon was 18.2%. This percentage is somewhat lower than that found in other studies (Nicholl & Williams, 1982; Maughan & Miller, 1983; Jakobsen et al., 1989). However, because these studies did not define their outcome it is difficult to compare with these data. The variation in the incidence of running-related injuries in the literature may in part be due to variations in the methodology. Also, the definition of a running injury may have caused differences between the studies.

The injury incidence expressed in exposure time was 3.2 injuries per 1000 running hours. It must be noted that our incidence rate expressed in exposure time could also include prevalent cases that were already present before the 12 months before the Rotterdam marathon. However, our result is supported by Lysholm and Wiklander (1987) and Van Galen and Diederiks (1990) who found incidence rates of, respectively, 3.6 and 2.5–5.8 per 1000 h of running exposure.

In this study, the most common site of lower extremity injuries when preparing for the Rotterdam marathon was the knee (30.7%). Other studies also found the knee to be the most common injured site of the body during running (Maughan & Miller, 1983; Jakobsen et al., 1989; Macera et al., 1989; Walter et al., 1989; Steinacker et al., 2001; Taunton et al., 2003). At our baseline measurement, the knee (26.7%) was the most common site of lower extremity injury, whereas during the marathon the calf (33.9%) was the most common injured site of the body. Satterthwaite et al. (1999) also found a high incidence of stiffness and pain in the calf in 45.3% of the subjects during or immediately after the race. Other marathon studies predominantly found the knee and the foot to be the most injured site of the body during a marathon (Maughan & Miller, 1983; Jakobsen et al., 1989; Satterthwaite et al., 1996; Steinacker et al., 2001). The high incidence of foot injuries reported in other studies can be explained by the fact that most of these studies also considered blisters as injuries.

Limitations

The response rate of the baseline questionnaire was 48.4%, which is somewhat lower than what we had

expected. Other athletics-based studies also had a relative high and comparable non-response (Egermann et al., 2003; Kazemi et al., 2005; McKean et al., 2006). For the baseline questionnaire, it was impossible to post reminders and to telephone the non-responders because of the anonymous mailing by a mail-order firm. Hence, unfortunately we do not have any information about the non-responders of the baseline questionnaire. Nevertheless, the response rate of the post-race questionnaire was very high; i.e. 95%. The 1-year prevalence of running injuries found in the present study might have been influenced by selection bias. Subjects who were already injured or recently had a running injury might have been more willing to participate, in which case the prevalence rates could have been overestimated. Furthermore, the 1-year prevalence of the injuries was obtained in a retrospective design from the first questionnaire. However, the incidence of running injuries shortly before and during the race was obtained with a prospective study design. Subjects were first included in the study and next they were prospectively observed for possible new injuries.

A further limitation of this study was that all information, including the information on injuries, was obtained by a self-administered questionnaire. For this reason, we do not have any meaningful information about the exact diagnosis of the injuries. Finally, the intention of this cohort study was to draw a random sample out of 10 000 male and female athletes. However, through a communication problem with the mail-order firm, the random sample was only performed within the male runners group. As a consequence, this study is about male recreational runners only.

Perspectives

This study has shown that running injuries are very common in male marathon runners. However, the pain intensity in rest of all injured runners was relatively low and most of the injured runners were able to carry out their work and ADL tasks within 1 week after the marathon. There was no systematic physical examination in this study, so the exact diagnosis of the injuries is unknown. However, we have good insight into the self-reported pain and discomfort of the running injuries reported by the runners themselves.

For future research it would be interesting to look at the different preparation strategies and explore possible risk factors for developing an injury during the marathon. This may enable development of strategies to prevent the occurrence of running injuries. Because the positive health effects are evident,

prevention of running injuries should have high priority.

Key words: runners, injuries, marathon, knee.

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