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Injury incidence and risk factors: a cohort study of 706 8-km or 16-km recreational runners

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ABSTRACT

Objectives To report (1) the injury incidence in recreational runners in preparation for a 8-km or 16-km running event and (2) which factors were associated with an increased injury risk.

Methods Prospective cohort study in Amsterdam, the Netherlands. Participants (n=5327) received a baseline survey to determine event distance (8 km or 16 km), main sport, running experience, previous injuries, recent overuse injuries and personal characteristics. Three days after the race, they received a follow-up survey to determine duration of training period, running distance per week, training hours, injuries during preparation and use of technology. Univariate and multivariate regression models were applied to examine potential risk factors for injuries.

Results 1304 (24.5%) participants completed both surveys. After excluding participants with current health problems, no signed informed consent, missing or incorrect data, we included 706 (13.3%) participants. In total, 142 participants (20.1%) reported an injury during preparation for the event. Univariate analyses (OR: 1.7, 95% CI 1.1 to 2.4) and multivariate analyses (OR: 1.7, 95% CI 1.1 to 2.5) showed that injury history was a significant risk factor for running injuries (Nagelkerke R-square=0.06).

Conclusion An injury incidence for recreational runners in preparation for a running event was 20%. A previous injury was the only significant risk factor for running-related injuries.

What are the new findings?

- Our results confirm the current literature that a previous injury is risk factor for running-related injuries.
- Use of a running app or sport watch was not related to running-related injury risk.
- Training characteristics were not risk factors for running-related injuries.

INTRODUCTION

In Western countries, a large group of people participate in running and this number is still increasing.[1–4] In 2014, running was the second most popular sport (12% of the population) in the Netherlands.[3] In addition, a large number of these runners participate in recreational running events.[2 5 6] Most participants in recreational running events are 30–55 years old (72%) and perform the sport individually or in a running group (68%).[5]

Health benefits associated with running include personal well-being, aerobic fitness, metabolic fitness, body mass, resting heart rate, VO2max, triglycerides and High-density lipoprotein cholesterol, cardiovascular function, running performance and adiposity.[7–9] However, the risk of sustaining a running injury is high, especially for novice runners. In 2014, 6.1 running injuries per 1000 hours were reported in the Netherlands.[10] Runners presented the highest injury incidence, followed by soccer and martial arts (both 4.3 per 1000 hours).[11] More recent analyses reported an incidence per 1000 running hours of 17.8 (95% CI 16.7 to 19.1) for novice runners, 7.7 (95% CI 6.9 to 8.7) for recreational runners,[12] a pooled injury proportion of 26.4% (95% CI 14.2 to 43.7) for novice runners and 28.0% (95% CI 23.1 to 33.5) in recreational runners.[13]

Injury history,[14–17] training characteristics, such as a greater training distance[14 16 18] and less running experience,[19 20] are common reported risk factors for general, lower extremity and specific running-related injuries (eg, knee injuries), in novice and recreational runners. There is less evidence in literature on novice and recreational runners that sex (male),[19 21] longer training duration and use of speed training,[22] lower weekly training volume[23 24] and lower weekly session frequency[23] are risk factors for general and lower extremity or back injuries.

Participants in recreational running events often use a running application (app) on a smartphone or a sport watch.[25 26] Using an app or a sport watch could be associated to the occurrence of injuries. It is unclear if the use of these technologies may increase or decrease the risk of injuries. On the one hand, these technologies may support and motivate the athlete before, during and after running.[25] On the other hand, these

tools often do not provide tailored coaching and/or could push runners to increase their running volume insensible, potentially resulting in injuries. Based on a retrospective study among experienced and novice runners, there was no relationship between the use of a smartphone app and risk of general running-related injuries.[27] To our knowledge, no prospective study has investigated the association between the use of running apps or sport watches and running injuries.

In current literature on risk factors for running-related injuries, studies have included specific types of runners, like novice and recreational runners who participated in a recreational event (Parkrun or 4 mile event),[19 21] a broad group of recreational runners,[22 23] trail runners[28] and short, moderate and long distance event runners.[16] Nevertheless, these studies did not focus on one cohort of runners who participate in a short and middle distance recreational running event. To investigate risk factors for running injuries among participants in a recreational running event, the Dam tot Damloop, a prospective study was designed. The Dam tot Damloop is one of the largest recreational running events in the Netherlands, with 65 000 participants each year. These runners can choose between a 8 km (Nightrun, 15 000 participants) and 16 km run (50 000 participants). A large variation of recreational and novice runners participate in this running event,[25] which provides the possibility to study risk factors in a broad group of recreational event runners.

The aim of this study was to determine (1) the injury incidence in recreational event runners in preparation for the Dam tot Damloop and (2) whether injury history, anthropometrics, training characteristics, event distance, main sport and use of technology were risk factors for injuries among participants in a recreational running event.

METHODS

Study population

A prospective cohort of participants in a recreational run in Amsterdam, the Netherlands (Dam tot Damloop) was studied. This event was organised on 18 September 2016.

In figure 1, the flowchart is presented. Inclusion criteria for this study were (1) ≥18 years old and (2) signed informed consent. Exclusion criteria were (1) reporting health problems in May 2016 (based on the Oslo Sports Trauma Research Center (OSTRC) questionnaire for health problems), (2) no signed informed consent, (3) missing demographics, (4) reporting an incorrect weight (not matching with other anthropometrics) or (5) missing data on the outcome.

The approved local medical ethical committee stated that no medical ethical approval was necessary for this study (http://www.ccmo.nl/nl/toetsingscommissie-ccmo-of-metc).

Procedure and measurements

When the runners registered online for the event (approximately 65 000), we asked them if they were interested in participating in a research on running injuries. All participants (8 and 16 km) who were willing to

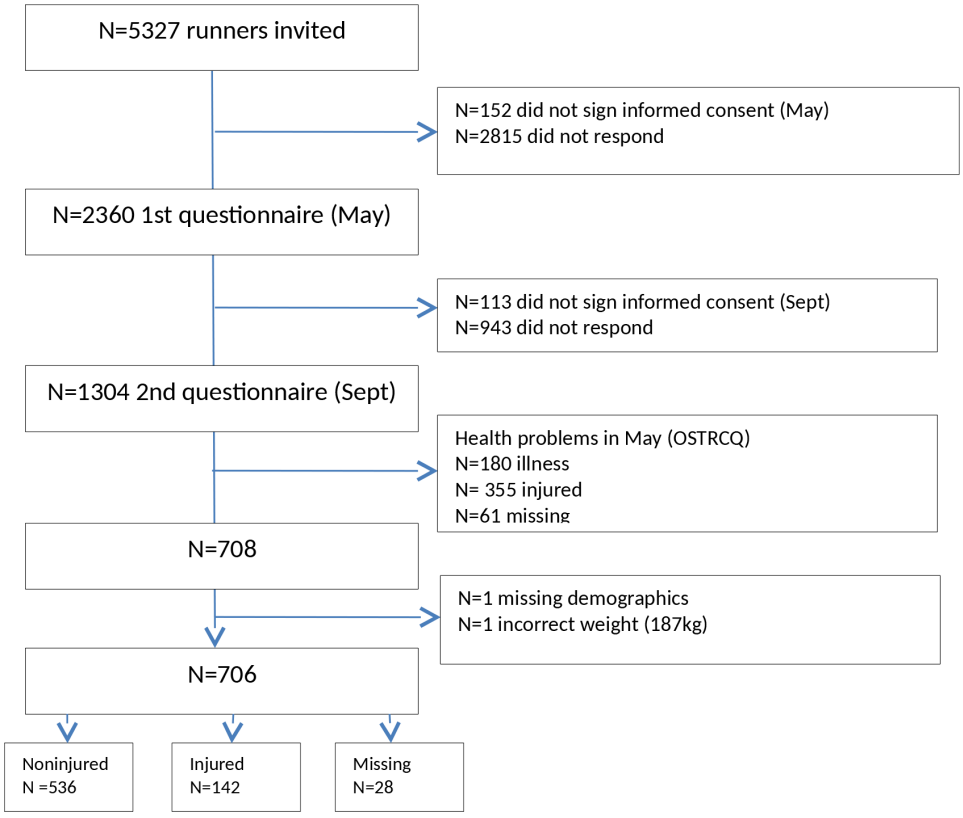

Figure 1 Flowchart of participants.

participate (n=5327) were invited by email to fill in an online survey 3 months prior to the event (May 2016). Runners of all levels were invited to participate. After 1 week and after 2 weeks, a reminder was sent to the participants who had not responded yet. The participants who filled in the first survey received a follow-up survey 3 days after the event. Again, two reminders were sent, one after 1 week and one after 2 weeks.

The first survey consisted of questions on registration for distance (8 or 16 km), if running was their main sport, on running experience, previous injuries (last year), recent overuse injuries and personal characteristics (age, gender and weight). Besides a survey on sport participation, the OSTRC questionnaire for health problems and a previously developed survey on event runners[5 29 30] were incorporated. Some questions were slightly adapted to make it suitable for recreational runners and for this event. The Dutch translation of the OSTRQ was used.[31 32] These questions were specified to running and complaints in the past 2 weeks were asked instead of the past week. For instance, one question was: 'Have you had any difficulties participating in running due to injuries, sickness or other health complaints during the past 2 weeks?'

With the follow-up survey information on duration of training period, running distance per week, training hours, injuries during preparation and use of technology (sport watch, apps) was gathered.

Injury registration

In the follow-up survey, we asked the participants whether they perceived long-term injuries in preparation for or during the event (Yes/No). A long-term injury was defined as every physical complaint that resulted in at least 1 week of training loss.

Statistical analysis

Statistical analyses were conducted using SPSS (SPSS, V.24.0) and statistical significance level was set at an alpha level of >0.05. Descriptive statistics were used to describe baseline characteristics of all participants using mean values and SD or number and percentages (%). Participants were only included in the analysis if they filled in both the baseline and follow-up survey.

To examine potential risk factors for running-related injuries, univariate and multivariate regression models were applied. Potential risk factors included age (years), gender (male), body mass index (kg/m^2), injury history in the previous year, training hours, running distance per week during preparation (<5 km, 5-10 km, 10-20 km, 20-30 km versus >30 km), length of training period (not or hardly, 1–5 weeks, 6–11 weeks, >12 weeks vs throughout the year), running as main sport (yes), use of a sport watch (yes), use of an app (yes), distance registered (8 km vs 16 km or both). First, univariate associations between the potential risk factors and the outcome (running-related injury sustained in preparation for or during the event [yes/no]) were assessed. Second, multivariate regression modelling was performed including all potential risk factors and the outcome of interest, a method also used by van Seters *et al* and Fokkema *et al*.[33 34] The results of the regression analyses were expressed in ORs with corresponding 95% CI.

RESULTS

Response rate

The response rate on the first survey was 44.3% (n=2360). Of this group, 55.3% responded on the follow-up survey. Overall, 24.5% filled in both surveys. As presented in figure 1, 706 (13.3%) participants were included in this study.

Baseline characteristics

Baseline characteristics of the included participants are presented in table 1.

Of the participants, 31.7% reported a previous injury in the last year. In regard to the previous injuries, the most reported location was the knee (22.0%), followed by the backside of the lower leg (14.9%) and Achilles tendon (10.2%). The mean duration of these previous injuries was 7.8±8.1 weeks. Most frequent reported diagnosis was a tendon injury, rupture, inflammation or bursitis (20.0%) or a muscle rupture or spasm (17.2%).

Apps were used by 46.2% of the participants; Runkeeper (32.8%), Nike+Running App (10.2%) and Runtastic (10.1%) were used most often. Sport watches were used by 58.0% of the participants.

Injury incidence

In total, 142 participants (20.1%) reported an injury during the preparation for the event. The knee and lower leg (back) were injured most often (both 19.0%) (table 1).

Risk factors

Univariate analyses showed that injury history was the only significant risk factor for running injuries (OR 1.67, 95% CI 1.14 to 2.44) (table 2). After multivariate analyses, we found that injury history was a significant predictor of running injuries as well (OR: 1.66, 95% 1.12 to 2.46). The use of an app or sport watch was not related to the occurrence of a running injury. In addition, no relationship was found between anthropometrics, training characteristics, event distance and main sport and occurrence of a running injury.

DISCUSSION

In this study of whether injury history, anthropometrics, training characteristics, main sport, event distance or use of technology were risk factors for general running injuries, injury history was the only significant predictor of running-related injuries. This extends findings from colleagues[14–17] who studied recreational runners, short and long distance runners or all types of runners.

Some explanations may be applicable for a previous injury being a risk factor. It could be that a runner did

Table 1 Baseline characteristics

	N=678
Gender (female)	331 (48.8%)
Age (years)	43.9 (11.6)
Height (cm)	177.2 (9.1)
Weight (kg)	74.8 (12.6)
BMI (kg/m^2)	23.7 (2.9)
Injury history last 12 months (yes)	215 (31.7%)
Main sport running (yes)	499 (73.6%)
Injured during event or in preparation	142 (20.1%)
Knee	27 (19.0%)
Lower leg (back)	27 (19.0%)
Achilles tendon	20 (14.1%)
Lower back	13 (9.2%)
Distance/week in preparation	
<5 km	50 (7.4%)
5–10 km	130 (19.2%)
10–20 km	255 (37.6%)
20–30 km	156 (23.0%)
>30 km	87 (12.8%)
Training period	
Not or hardly	48 (7.1%)
1–5 weeks training	52 (7.7%)
6–11 weeks training	65 (9.6%)
>12 weeks	89 (13.1%)
Training throughout the year	424 (62.5%)
Training hours (training period)	50.9 (95.6)
Use of a sport watch	
Yes	393 (58.0%)
No	285 (42.0%)
Use of an application	
Yes	313 (46.2%)
No	365 (53.8%)
Registered for	
8 km	128 (18.9%)
16 km	521 (76.8%)
Both distances	29 (4.3%)

BMI, body mass index.

not recover completely from a previous injury.[14 35] Our survey did not include a question regarding the time of injury onset. Therefore, it could be that the previous injury occurred shortly before the reinjury. Besides, it could be that a previous injury has caused a change in biomechanical movement patterns. This may lead to overload of other structures or joints resulting in a new injury.[15 36]

In this study, other variables, such as training characteristics (training frequency, duration and distance) were not related to injury occurrence, whereas other studies showed that greater training distance[14 16 18] and less running experience were risk factors for running-related injuries.[19 20] Possible explanations for this difference might be the differences in study design, population (size), way of measuring the variables (continue or categorical), type of injury included and injury definition. For instance, we measured training distance in categories, while van Poppel *et al*[16] measured training distance as a continuous variable in kilometres. In addition, a review of van der Worp and colleagues[14] included both prospective studies as retrospective studies. They included studies that examined specific injuries, such as hip, hamstrings and calf injuries as well. It is important to note that a low explained variance of the multivariate model was found; therefore, future studies are needed to further investigate risk factors for running-related injuries. Moreover, as described previously,[20] different aspects of training characteristics (running volume, intensity, duration and frequency) might interact and these interactions should be further examined in relation to injury risk.

Interestingly, the use of an app or sport watch was not related to occurrence of injuries. These results reflect those of Kemler *et al*,[27] who also did not find an association between the use of running applications with an increased risk of injuries in experienced and novice runners. In this study, runners who trained at least 4 weeks in the last year were included; however, they were not preparing for a particular running event.[27]

One fifth of participants sustained an injury and this extends work from other studies (varying from 22% to 28.0%),[13 21] also in a Dutch population. Those two studies focused on lower limb or back injuries, whereas our study analysed running injuries, regardless of the body region. The percentage of upper body injuries in our study was small (6.5%). In recreational event runners, a slightly lower extremity injury incidence was found; 17.5% for 5 km runners and 18.7% for 10–15 km runners. Compared with other sports the injury incidence in running was relatively high.[11]

Strengths and limitations

The strengths of this survey study were the prospective design and the inclusion of a large population of novice and recreational runners in preparation for a running event. Limitations include self-report of data including injury. Novice runners can accurately report injury location but not injury type.[37] Injury recall seemed to be higher when less detailed information was requested.[38] In our study, the occurrence of a previous injury (yes/no) was the included as potential risk factor. Therefore, the inaccuracy of occurrence of previous running-related injuries was expected to be low.

Another limitation was that previous injury was defined as every physical complaint that caused at least a week of training loss. We collected location, diagnosis and duration of injuries, but we do not know the time of injury onset. We acknowledge that the group of participants

Table 2 Univariate and multivariate models of potential risk factors for all injuries

	Non-injured (n=536)	Injured (n=142)	Univariate	Multivariate
			OR (95% CI)	OR (95% CI)
Age (years)	44.04 (11.65)	43.46 (11.81)	1.00 (0.98 to 1.01)	1.00 (0.98 to 1.02)
Gender (male)	273 (50.9%)	74 (52.1%)	1.05 (0.72 to 1.52)	0.96 (0.61 to 1.49)
BMI (kg/m^2)	23.62 (2.87)	24.08 (3.08)	1.05 (0.99 to 1.12)	1.05 (0.98 to 1.13)
Injury history (yes)	157 (29.3%)	58 (40.8%)	**1.67 (1.14 to 2.44)**	**1.66 (1.12 to 2.46)**
Training hours	50.18 (93.9)	53.37 (101.9)	1.00 (0.999 to 1.002)	1.00 (0.999 to 1.003)
Distance/week preparation				
<5 km	36 (6.7%)	14 (9.9%)	2.03 (0.87 to 4.70)	2.99 (0.99 to 9.07)
5–10 km	96 (17.9%)	34 (23.9%)	1.85 (0.92 to 3.69)	1.98 (0.89 to 4.41)
10–20 km	206 (38.4%)	49 (34.5%)	1.24 (0.65 to 2.38)	1.15 (0.57 to 2.32)
20–30 km	125 (23.3%)	31 (21.8%)	1.29 (0.65 to 2.59)	1.20 (0.58 to 2.47)
>30 km	73 (13.6%)	14 (9.9%)	Ref.	Ref.
Training period				
Not or hardly	38 (7.1%)	10 (7.0%)	1.13 (0.54 to 2.37)	0.71 (0.26 to 1.92)
1–5 weeks	39 (7.3%)	13 (9.2%)	1.43 (0.73 to 2.81)	1.18 (0.57 to 2.42)
6–11 weeks	47 (8.8%)	18 (12.7%)	1.65 (0.91 to 2.99)	1.63 (0.87 to 3.03)
>12 weeks	68 (12.7%)	21 (14.8%)	1.33 (0.77 to 2.29)	1.30 (0.73 to 2.30)
Throughout the year	344 (64.2%)	80 (56.3%)	Ref.	Ref.
Main sport running (yes)	395 (73.7%)	104 (73.2%)	1.02 (0.67 to 1.56)	0.86 (0.54 to 1.38)
Use of a sport watch (yes)	309 (57.6%)	84 (59.2%)	1.06 (0.73 to 1.55)	1.19 (0.78 to 1.84)
Use of an application (yes)	242 (45.1%)	71 (50.0%)	1.22 (0.84 to 1.76)	1.19 (0.78 to 1.80)
Registered for				
8 km	103 (19.2%)	25 (17.6%)	Ref.	Ref.
16 km	407 (75.9%)	114 (80.3%)	1.15 (0.71 to 1.87)	1.45 (0.83 to 2.50)
Both	26 (4.9%)	3 (2.1%)	0.48 (0.13 to 1.70)	0.65 (0.17 to 2.45)

Bold numbers indicate significant risk factors
BMI, body mass index.

included in the analyses was small (13.3%). A large group of participants was excluded because of current health problems. The response on the baseline survey was high compared with a previous study (44% vs 21%);[16] however, our response on the follow-up survey was lower (55% vs 73%).

CONCLUSION

The injury incidence was 20.1% for recreational runners in preparation for a running event. A previous injury was the only significant risk factor for running-related injuries. We conclude that secondary injury prevention programmes are needed and that sport organisations should provide information and injury prevention programmes in an effort to limit reinjury in their participants.

Use of a running app or sport watch did not increase or decrease the risk for a running-related injury. These preliminary data suggest that these technologies could be used in the preparation for a running event without placing the athlete at a risk of a running injury.

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