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Original research

Prognosis and prognostic factors of running-related injuries in novice runners: A prospective cohort study

Tryntsje Fokkema[a,*], Robert Burggraaff[a], Fred Hartgens[b], Bas Kluitenberg[c], Evert Verhagen[d], Frank J.G. Backx[e], Henk van der Worp[c], Sita M.A. Bierma-Zeinstra[a,f], Bart W. Koes[a], Marienke van Middelkoop[a]

[a] Department of General Practice, Erasmus MC, University Medical Center Rotterdam, The Netherlands
[b] Departments of Epidemiology and Surgery, Research School CAPHRI, Maastricht University Medical Center+, Sports Medicine Center Maastricht, The Netherlands
[c] Center for Sports Medicine, University of Groningen, University Medical Center Groningen, The Netherlands
[d] Amsterdam Collaboration on Health & Safety in Sports, Department of Public and Occupational Health, Amsterdam Movement Sciences, VU University Medical Center, Amsterdam, The Netherlands
[e] Department of Rehabilitation, Physical Therapy Science & Sports, Rudolf Magnus Institute of Neurosciences, University Medical Center Utrecht, The Netherlands
[f] Department of Orthopedics, Erasmus MC, University Medical Center Rotterdam, The Netherlands

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ABSTRACT

Objectives: To investigate the prognosis and possible prognostic factors of running-related injuries (RRIs) in novice runners.
Design: Prospective cohort study.
Methods: Participants of Start to Run, a 6-weeks course for novice runners in The Netherlands, were asked to participate in this study. Before the start of the course a baseline questionnaire, on demographics, physical activity and perceived health, was sent to runners willing to participate. The 26- or 52-weeks follow-up questionnaires assessed information on RRIs and their duration. Only participants that sustained a RRI during follow-up were included in the analyses. An injury duration of 10 weeks or shorter was regarded as a relatively good prognosis, while an injury duration of more than 10 weeks was defined as a poor prognosis. To determine the associations between baseline characteristics and injury prognosis and between injury location and injury prognosis, multivariable logistic regression analyses were performed.
Results: 347 participants (48.8%) sustained an RRI during follow-up. The RRIs had an overall median duration of eight weeks (range: 1–52 weeks). Participants with a previous RRI were more likely to have a poor prognosis (OR 2.31; 95%CI 1.12–4.79), while a calf injury showed a trend towards an association with a relatively good prognosis (OR 0.49; 95%CI 0.22–1.11).
Conclusions: The duration of RRIs in novice runners is relatively long, with only calf injuries being associated with a good prognosis. This emphasizes the need of injury prevention measures in novice runners and adequate support during and after an RRI, especially in runners with a previous injury.

1. Introduction

Running is one of the most popular forms of physical activity in Western countries.[1] For example, in the Netherlands the number of runners has increased over the last years to a running population of more than two million (about 12.5% of the Dutch population) in 2014.[2] Motives to start running include the health benefits (i.e. weight reduction), the low entry level and social elements.[3] It has been shown that running has a positive effect on both physical and mental well-being.[4] However, contradictory to the positive aspects of running, injury rates among runners are high, especially in novice runners.[5,6] These injuries can cause absence from sports, as well as from work, and can increase health care utilization.[7] Moreover, injuries can cause drop-out from running and other activities. Therefore, it is important to gain more insight in the impact of running related injuries (RRIs).

Van Middelkoop et al. performed a study on the course and 3-month prognosis of RRIs in male marathon runners and found that

* Corresponding author.
E-mail address: t.fokkema@erasmusmc.nl (T. Fokkema).

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25.5% of the injured runners still reported persistent complaints after three months follow-up.[8] Furthermore, runners that reported non-musculoskeletal comorbidities were more likely to have prolonged complaints of their injury, while runners who sustained a calf injury recovered relatively fast from this injury. Nielsen et al. described the time to recovery of RRIs in novice runners.[9] A median recovery time of 72 up to 87 days was found for the most common injuries (medial tibial stress syndrome, patellofemoral pain and meniscus injury). Though prognostic factors were not investigated in this study. More knowledge on the prognostic factors for RRIs in novice runners may assist in future guidance of clinicians in the treatment and education towards injured novice runners. Even if non-modifiable prognostic factors are identified, these may help to better inform runners on the prognosis of their RRI. Therefore, the aim of this study was to investigate the prognosis and possible prognostic factors of RRIs in novice runners.

2. Methods

This study was part of the NLStart2Run study.[10] Novice runners who signed up for Start to Run, a 6-week running course for novice runners, in March or September 2013 were informed about the NLStart2Run study. Runners that were interested in participating in the study were asked to sign a digital informed consent form and complete the online baseline questionnaire one week before the start of the course. The follow-up questionnaire was sent 52 weeks later to the participants that started Start to Run in March and 26 weeks later to the participants starting in September. The difference in follow-up duration was due to practical and financial reasons. Participants aged between 18 and 65 years, who sustained an RRI since the start of the NLStart2Run study were included in the analyses of the current study. The NLstart2run study was approved by the Medical Ethics Committee (number 2012/350) of the University Medical Center Groningen, The Netherlands and registered in the Netherlands Trial Registry (NTR3676).

Start to Run is a course for novice runners organized by the Dutch Athletics Federation. In 2013 the goal of the course was to be able to run for 20 consecutive minutes after a period of six weeks. Each training week consisted of one group training session, guided by a licensed athletics trainer, and one or two individual, non-supervised sessions. The duration and intensity of running gradually increased during the 6-weeks program.

In the baseline questionnaire information on demographics (sex, age, weight and height) was assessed. Weight and height were used to calculate the body mass index (BMI). Furthermore, participants were asked if they smoked (yes/no/in the past) and if they wore orthotics in their daily shoes (yes/no). Sport experience was administered with questions on previous running experience (yes/no and if yes, more or less than one year ago) and experience with other sports in the last 12 months. Moreover, participants with previous running experience were asked if they ever had an RRI (yes/no) and all participants were asked about previous musculoskeletal complaints (yes/no and if yes, if the complaints were attributed to sports). The RAND 36-item Health Survey (RAND-36), which is a Dutch translation of the SF-36 Health Survey, was used to administer the perceived health.[11,12] In this study only the scores on the subscales perceived health, mental health, vitality and general health (0–100, with higher scores indicating a better perceived health) were used. Motivation towards exercise was measured using the Behavioral Regulation in Exercise Questionnaire 2 (BREQ-2).[13] With the score on the five subscales of the BREQ-2 the Relative Autonomy Index (RAI-score) was calculated, with higher RAI-scores indicating a higher level of intrinsic motivation. Finally, physical activity in daily life was assessed with the Short Questionnaire to Assess Health (SQUASH).[14] A higher score on the SQUASH indicates a higher physical activity level in daily life.

In the follow-up questionnaire the participants were asked if they sustained an RRI since the start of the running program (yes/no). Participants who reported an RRI were asked to indicate the location of their RRI on a body chart. Participants that sustained more than one injury could select multiple locations. Furthermore, information on the duration of the RRI in weeks was asked. Finally, the injured participants were asked if they fully recovered from the RRI already (yes/no).

The primary outcome measure of this study was the duration of the RRIs. An RRI was defined as a self-reported complaint in the lower extremities or lower back caused by running that occurred since the start of the running course. The RRI must have been severe enough to cause a reduction in running for at least one week.[10] Therefore, only RRIs with a duration of at least one week were included in the analyses of this study. The duration of the RRIs was defined as the total duration of the complaints of the RRI in weeks as reported in the follow-up questionnaire. For participants that still suffered their RRI when filling in the follow-up questionnaire, RRI duration was defined as the duration of the complaints so far. Based on Nielsen et al., who found a median RRI duration of 10 weeks in novice runners, the duration of the RRIs was dichotomized into a good prognosis (duration shorter than or equal to 10 weeks) and poor prognosis (duration longer than 10 weeks)[9].

Participants that completed the follow-up questionnaire and participants that did not complete the follow-up questionnaire were compared using independent sample t-tests, Mann-Whitney U tests and chi-square tests. Descriptive statistics were used to describe baseline and injury characteristics. To visualize the course of recovery of the RRIs over the study period, two Kaplan-Meier survival curves (one for the 26 weeks and one for the 52 weeks follow-up) were made with the recovery of the RRI as the event. Differences in time-to-recovery between the two follow-up groups were tested with a log-rank test. Univariate logistic regression models were used to determine the associations between the baseline characteristics and a poor prognosis. Next, multivariable logistic regression analysis (enter-method) was performed using the same baseline characteristics as independent variables. To determine the associations between the injury location and RRI prognosis, both univariate and multivariable logistic regression analyses were performed with prognosis as dependent variable and the injury locations (lower back/hip/groin, anterior thigh, posterior thigh, knee, shin, calf, ankle, Achilles tendon, foot) as independent variables. All regression analyses were adjusted for the follow-up duration (26 or 52 weeks). In the multivariable logistic regression analysis for injury location, the presence of multiple injuries during follow up (yes/no) was included as an additional variable. Results of the logistic regression analyses are presented as odds ratios (OR) with 95% confidence intervals. P-values <0.05 were regarded as significant. All analyses were conducted with the SPSS software package (version 21; 2011, Inc., Chicago, IL).

3. Results

In 2013, 7660 novice runners registered for Start to Run, of which 1772 participated in the Start2Run-study (Appendix A). The follow-up questionnaire was completed by 727 participants (41.0%). The group of participants that filled in the follow-up questionnaire were on average older (mean 44.7 (SD 10.1) vs. 42.1 (9.9) years, $p < 0.001$), more often male (25.9 vs. 18.9%, $p = 0.001$), had previous experience with running (43.2 vs. 37.0%, $p = 0.010$) and other sports (48.4 vs. 39.1%, $p < 0.001$) more often, had previous RRIs more often (20.4 vs. 15.3%, $p = 0.006$) and scored on average higher on the RAND-36 questionnaire subscales mental health (mean 75.3 (SD 14.8) vs.

Table 1
Baseline characteristics of injured runners and of runners with a good and poor prognosis.

Factor		RRI during follow-up[a]	Good prognosis (≤10 weeks)	Poor prognosis (>10 weeks)
N		347	220	127
Sex	*Female*	232 (66.9%)	138 (62.7%)	94 (74.0%)
Age (years)		45.0 (9.4)*	45.8 (9.4)*	43.8 (9.1)*
BMI (Kg/m^2)[b]		25.6 (3.7)*	25.5 (3.4)*	25.9 (4.1)*
Smoking	*Currently smoking*	26 (7.5%)	17 (7.7%)	9 (7.1%)
	Stopped smoking	140 (40.3%)	90 (40.9%)	50 (39.4%)
	Never smoked	181 (52.2%)	113 (51.4%)	68 (53.5%)
Running experience	*None*	189 (54.5%)	123 (55.9%)	66 (52.0%)
	Yes, more than a year ago	112 (32.3%)	71 (32.3%)	41 (32.3%)
	Yes, less than a year ago	46 (13.3%)	26 (11.8%)	20 (15.7%)
Previous RRI[a]	*Yes*	83 (23.9%)	43 (19.5%)	40 (31.5%)
Previous sport activity (last 12 months)	*Yes*	175 (50.4%)	108 (49.1%)	64 (50.4%)
Previous musculo-skeletal complaints	*None*	213 (61.4%)	137 (62.3%)	76 (59.8%)
	Yes, not attributed to sports	67 (19.3%)	41 (18.6%)	26 (20.5%)
	Yes, attributed to sports	67 (19.3%)	42 (19.1%)	25 (19.7%)
Orthotics in daily shoes	*Yes*	47 (13.5%)	27 (12.3%)	20 (15.7%)
BREQ-2[c]	*RAI-score*[d]	11.1 (4.9)*	11.0 (5.1)*	11.3 (4.7)*
SQUASH[e]	*Score*	6480.5 (3431.8)*	6431.4 (3618.2)*	6565.5 (3094.4)*
RAND36[f]	*Physical functioning*	91.5 (10.9)*	91.9 (10.3)*	90.6 (12.0)*
	Mental Health	75.2 (15.1)*	76.2 (13.9)*	73.4 (16.9)*
	Vitality	62.7 (16.6)*	64.0 (15.9)*	60.6 (17.5)*
	General health perception	70.5 (17.0)*	71.2 (16.1)*	69.4 (18.5)*

Categorical data are presented as N (%) and continuous data (*) as means (SD).
[a] RRI = Running-related injury.
[b] Body Mass Index.
[c] Behavioral Regulation in Exercise Questionnaire 2.
[d] Relative Autonomy Score.
[e] Short Questionnaire to Assess Health.
[f] RAND-36 Item Health Survey.

72.5 (16.3), p = 0.001), general health perception (mean 72.5 (SD 15.6) vs. 69.3 (17.2), p < 0.001) and vitality (mean 63.1 (SD 16.8) vs. 59.9 (18.4), p < 0.001) than the groups of participants that did not complete the follow-up questionnaire. Of the participants that completed the follow-up questionnaire, 355 participants (48.8%) reported an RRI during follow-up. Eight of these injured participants did not report the duration of their RRI and therefore a total of 347 participants were included in the analyses.

The included participants were on average 45.0 (SD 9.4) years old, had an average BMI of 25.6 (SD 3.7) kg m^{-2} and the majority was female (66.9%) (Table 1). About one-third of the participants (32.3%) had previous running experience more than a year ago and 13.3% less than a year ago, while 23.9% of the participants sustained an RRI before. Other previous musculoskeletal complaints were present in 38.6% of the participants.

During the follow-up period the 347 participants sustained 513 RRIs (Table 2). Multiple injury locations were reported by 35.7% of the participants. The knee (25.0%), lower back/hip/groin (15.4%) and the Achilles tendon (14.4%) were injured most frequently. The overall median duration of the RRIs was eight weeks. Injuries of the anterior thigh had the shortest median duration (5 weeks), while injuries of the Achilles tendon and posterior thigh had the longest median duration (9 weeks). The Kaplan–Meier curve showed that there was a significant difference in the distribution of the time-to-recovery of the RRIs between the two follow-up groups (26 and 52 weeks) (p = 0.012) (Appendix B).

Results of the univariate and multivariable logistic regression analyses for prognostic factors are presented in Table 3. The univariate analyses showed that being female (OR 1.68; 95% CI 1.03–2.73) and a previous RRI (OR 1.87; 95% CI 1.13–3.11) were significantly associated with a poor prognosis of RRIs. In the multivariable logistic regression analysis, a previous RRI (OR 2.31; 95%CI 1.12–4.79) was related to a poor prognosis. In the univariate logistic regression analyses for injury location an RRI located in the calf (OR 0.42; 95% CI 0.21–0.82) was negatively associated with a poor prognosis (Table 2). Also in the multivariable analysis, a follow-up duration of 52 weeks (OR 1.73; 1.08–2.77) was associated with a poor prognosis. A trend towards a negative association between an RRI located in the calf (OR 0.49; 95%CI 0.22–1.11) and a poor prognosis was seen.

4. Discussion

The aim of this study was to investigate the prognosis and possible prognostic factors for time to recovery of RRIs in novice runners. The median duration of the RRIs was eight weeks. Runners who suffered an RRI before had a higher chance of a poor prognosis (>10 weeks) of their new injury. Furthermore, an RRI in the calf seemed to be associated with a relatively good prognosis (≤10 weeks).

In the current study an RRI incidence rate of 48.8% was found, which is within the range (10.3–75.6%) of studies with a comparable follow-up period[15–17]. In addition, the injury locations were comparable to earlier studies, with the knee, Achilles tendon and shin as most frequently injured sites.[1,18] The median duration of the injuries (8 weeks) was a bit shorter than the median duration in the only other study on the prognosis of injuries in novice runners (10 weeks)[9]. The median duration of eight weeks is a substantial injury duration when compared to the prognosis of injured marathon runners. In a study on male marathon runners, 60% of the participants that suffered an RRI recovered within one month[8]. This shows that RRIs are not only common in novice runners[15], but that the duration of injuries is also relatively long in this group of runners. This emphasizes the need for suitable guidance of injured novice runners, especially in runners who suffered an RRI before.

This study showed that, next to the often identified risk factor for sustaining an RRI,[1,19] a previous injury is also a risk factor for a poor prognosis of RRIs. Possible explanation might be that the runners did not completely recover from their previous RRI or that structural errors exist in the training or running pattern, what might have caused a more severe 'new' RRI.[16,20,21] Another explanation might be that runners who suffered an RRI before are more prone to RRIs and therefore also sustain more serious RRIs. Unfortunately this cannot be determined from the results of the

Table 2
Anatomical distribution of running-related injuries with corresponding duration of complaints in weeks and the results of the univariate and multivariable logistic regression analyses of injury location associated with poor prognosis.

	Number (%)	Duration of complaints (weeks)	Univariate analysis		Multivariable analysis	
		[Median (range) *Mean (SD)]*	OR (95% CI)	P-value	OR (95% CI)	P-value
Lower back/hip/groin	79 (15.4)	8.0 (1–52) *12.8 (12.9)*	0.88 (0.52–1.50)	0.64	1.01 (0.50–2.02)	0.98
Anterior thigh	11 (2.1)	5.0 (2-24) *8.6 (7.1)*	0.32 (0.07–1.54)	0.16	0.38 (0.07–2.15)	0.28
Posterior thigh	19 (3.7)	9.0 (2–52) *12.1 (11.8)*	1.33 (0.52–3.43)	0.56	2.30 (0.75–7.10)	0.15
Knee	128 (25.0)	8.0 (2–52) *12.6 (12.0)*	1.11 (0.70–1.75)	0.66	1.19 (0.63–2.25)	0.59
Shin	60 (11.7)	8.0 (1–52) *11.7 (10.7)*	1.05 (0.59–1.87)	0.87	1.27 (0.60–2.69)	0.53
Calf	58 (11.3)	8.0 (1–50) *9.7 (9.6)*	0.42 (0.21–0.82)	0.01	0.49 (0.22–1.11)	0.09
Ankle	43 (8.4)	7.0 (2–52) *10.8 (11.1)*	0.77 (0.39–1.56)	0.47	0.94 (0.41–2.14)	0.88
Achilles tendon	74 (14.4)	9.0 (2-52) *13.8 (12.2)*	1.31 (0.77–2.23)	0.31	1.61 (0.81–3.20)	0.17
Foot	41 (8.0)	8.0 (2–52) *13.3 (12.4)*	0.86 (0.43–1.71)	0.66	1.06 (0.47–2.39)	0.88
Multiple injuries (yes)			0.65 (0.41–1.04)	0.65	0.59 (0.26–1.36)	0.21
Total	513 (100)	8.0 (1–52) *12.0 (11.2)*				

All logistic regression analyses are adjusted for follow-up duration.

Table 3
Univariate and multivariable logistic regression analyses of prognostic factors associated with a poor prognosis.

Factor	Qualifier	Univariate analysis		Multivariable analysis	
		OR (95% CI)	P-value	OR (95% CI)	P-value
Follow-up duration	*52 weeks*	1.75 (1.11–2.76)	0.02	1.84 (1.12–3.02)	0.02
Sex	*Female*	1.68 (1.03–2.73)	0.04	1.58 (0.91–2.74)	0.11
Age (Years)		0.98 (0.96–1.00)	0.07	0.98 (0.95–1.01)	0.12
BMI (kg/m^2)[a]		1.04 (0.98–1.10)	1.04	1.05 (0.98–1.12)	0.15
Smoking	*Never smoked*	Reference		Reference	
	Currently smoking	1.09 (0.45–2.63)	0.86	0.97 (0.38–2.48)	0.95
	Stopped smoking	1.15 (0.48–2.74)	0.76	1.01 (0.61–1.67)	0.97
Running experience	*No*	Reference		Reference	
	Yes, >1 year ago	1.11 (0.68–1.82)	0.67	0.73 (0.38–1.40)	0.34
	Yes, <1 year ago	1.48 (0.76–2.87)	0.25	0.83 (0.35–1.96)	0.68
Previous RRI[b]	*Yes*	1.87 (1.13–3.11)	0.02	2.31 (1.11–4.79)	0.03
Previous sports activity	*Yes*	1.09 (0.70–1.69)	0.71	1.09 (0.66–1.80)	0.74
Previous musculo-skeletal complaints	*No*	Reference		Reference	
	Yes, not attributed to sports	1.19 (0.67–2.10)	0.56	1.14 (0.61–2.14)	0.68
	Yes, attributed to sports	1.13 (0.64–2.02)	0.67	0.99 (0.53–1.86)	0.97
Orthotics daily shoes	*Yes*	1.35 (0.72–2.54)	0.35	1.31 (0.65–2.64)	0.45
BREQ-2[c]	*RAI-score*[d]	1.01 (0.96–1.06)	0.71	1.02 (0.96–1.07)	0.60
SQUASH[e]		1.00 (1.00–1.00)	0.76	1.00 (1.00–1.00)	0.83
RAND-36[f]	*Physical functioning*	0.99 (0.97–1.01)	0.16	0.99 (0.97–1.02)	0.46
	Mental health	0.99 (0.97–1.00)	0.08	0.99 (0.97–1.01)	0.29
	Vitality	0.99 (0.98–1.00)	0.08	1.00 (0.98–1.02)	0.93
	General health perception	0.99(0.98–1.01)	0.22	1.00 (0.98–1.02)	0.89

All analyses are adjusted for follow-up duration.
[a] Body Mass Index.
[b] Running related injury.
[c] Behavioral Regulation in Exercise Questionnaire 2.
[d] Relative autonomy score.
[e] Short Questionnaire to Assess Health.
[f] RAND-36 Item Health Survey.

current study. Therefore, more research on recurrent RRIs, the relationship between recurrences and specific risk factors for recurrent RRIs should be performed.

Despite that RRIs in the anterior thigh had the shortest median duration, calf injuries tended to have a relatively good prognosis. This finding is in accordance with a study performed in male marathon runners, in which calf injuries also had a relatively good prognosis.[8] In these male marathon runners the calf injuries were mostly self-diagnosed as cramps, strain and overload and it was suggested that these types of injuries recover relatively fast[8]. Furthermore it can be hypothesized that calf injuries are often muscle injuries, which recover faster than for example tendon injuries.[22,23] Since the present study collected no information on the type of injury, it remains unknown if the type of injury explains the relatively good prognosis of calf injuries.

A strength of this study is that it is the first study providing data on a broad spectrum of prognostic factors of RRIs in novice runners. Other strengths include the prospectively measured prognostic factors at baseline and relative large study population.

There are, however, some limitations that have to be taken into account when interpreting the results of this study. A limitation is that there were two follow-up durations (26 and 52 weeks), due to

practical and financial reasons. There was a significant difference in the distribution of the RRI duration between the two follow-up groups. Therefore, we adjusted all regression analyses for the follow-up duration. Additional sensitivity analyses (data not presented) showed that the regression analyses without adjustment for follow-up duration showed similar results as the analyses with adjustment for follow-up duration. Additionally, analyses of prognostic factors in the two cohort groups (26 and 52 weeks follow up) separately showed similar results as analyzing the participants in one group, as presented in the current study. This confirms the robustness of the analyses by combining the data of the two groups with a different follow up duration.

However, the shorter follow-up of part of the study population may still have led to an underestimation of the RRI duration, since part of the study population was followed shorter and the maximal duration of complaints following their RRIs was therefore shorter. Additionally, 15% of the injured participants reported an RRI with, at the moment of filling in the questionnaire, a duration of 10 weeks or less with no full recovery yet. For these participants that still suffered their RRI when filling in the follow up questionnaire, the RRI duration was set at the duration of the complaints so far. Therefore, some of these RRIs may have been classified as having a good prognosis while they actually have lasted more than 10 weeks. This might have led to misclassifications of some of the injuries and an underestimation of RRI duration in this study.

This study had a follow-up of 26 or 52 weeks, so for some participants there may have been quite some time between their RRI and the follow-up questionnaire. This may have caused recall bias in the injury characteristics. Moreover, this may have led to an underestimation of RRIs with a relatively good prognosis, since less severe RRIs with a shorter time loss will be forgotten more easily than severe injuries with more time loss.

Another limitation is that participants were able to report multiple RRIs at different locations in the follow-up questionnaire. Though, injury duration could only be reported once. About 35% of the participants reported two or more injuries during the follow-up period. It is likely that these participants reported the duration of the injury with the longest duration. This may have led to an overestimation of the RRI duration per anatomical site and of all injuries taken together.

Finally, the percentage loss to follow-up (59.0%) was relatively high, which might have influenced the results. Since there were significant differences between the participants that did and did not complete the follow-up questionnaires, it seems that the relatively fit and older aged males were more likely to respond to the follow-up questionnaires. Therefore, the results may only apply to this selected population.

5. Conclusion

This study showed that the median duration of RRIs in novice runners was eight weeks (range 1–52 weeks). A previous RRI was associated with a higher chance of a poor prognosis of the current RRI, which emphasizes the need for well-founded rehabilitation programs and injury prevention measures in novice runners.

Practical implications

- Therapists and athletic trainers should be aware that the duration of RRIs in novice runners is relatively long.
- This relative long duration emphasizes the need for well-founded rehabilitation programs and injury prevention measures in novice runners.
- Since a previous RRI is related to a higher chance of a new RRI with a poor prognosis, there is need of supervision of novice runners during the restart of running after an RRI.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jsams.2018.09.001.

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