Chapter 4

The NLstart2run study: incidence and risk factors of running-related injuries in novice runners.

Bas Kluitenberg, Marienke van Middelkoop, Dirk-Wouter Smits, Evert Verhagen, Fred Hartgens, Ron Diercks, Henk van der Worp

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ABSTRACT

Running is a popular form of physical activity, despite of the high incidence of running-related injuries (RRIs). Due to methodological issues, the etiology of RRIs remains unclear. Therefore, the purposes of the study were to assess the incidence of RRIs and to identify risk factors for RRIs in a large group of novice runners.

In total, 1,696 runners of a 6-week supervised “Start to Run” program were included in the NLstart2run study. All participants were aged between 18 and 65, completed a baseline questionnaire which covered potential risk factors and completed at least one running diary. RRIs were registered during the program with a weekly running log. An RRI was defined as a musculoskeletal complaint of the lower extremity or back attributed to running and hampering running ability for three consecutive training sessions.

During the running program, 10.9% of the runners sustained an RRI. The multivariable Cox regression analysis showed that a higher age, higher BMI, previous musculoskeletal complaints not attributed to sports and no previous running experience were related to RRI.

These findings indicate that many novice runners participating in a short-term running program suffer from RRIs. Therefore, the identified risk factors should be considered for screening and prevention purposes.
INTRODUCTION
Running is a popular form of vigorous-intensive physical activity. About 13% of the Dutch population participates in running as a type of recreational exercise on a regular basis [1]. Important reasons for participation in recreational running are most likely the positive health effects resulting from running [2, 3].

The high incidence of running-related injuries (RRIs), which is reported up to 79%, is contradictory to the positive health effects [4-7]. Especially novice runners are at high risk of sustaining an RRI [8-10]. Besides, the occurrence of an RRI is an important reason for dropout from running [11]. Therefore, it is of particular importance to prevent RRIs in a running program for novice runners, because this will increase running persistence and thereby contribute to public health.

The identification of factors that increase injury susceptibility is an important step towards prevention of RRIs [12]. Risk factors for injury can be divided into intrinsic factors (e.g. gender, age and BMI) and extrinsic factors (e.g. running shoes, training program and running surface). The development of an RRI results from the complex interaction between both intrinsic and extrinsic factors [13].

There is some evidence that higher BMI, increased age, no previous running experience, previous injuries and previous sports participation are associated with RRIs in novice runners [9, 14, 15]. However, these studies reported conflicting results, which might be explained by non-standardized training schedules or due to pre-selection of potential risk factors which were entered into the multifactorial analysis. For identification of risk factors for RRIs, multiple factors should be analyzed simultaneously in a multifactorial model. This form of analysis, however, is sensitive for bias when more than one variable is entered into the model per 10 occurred injuries [16]. Because of small sample sizes, previous prospective cohort studies on RRIs in novice runners could only investigate a limited number of potential risk factors [14, 17, 18]. To overcome the pre-selection of potential risk factors and create a multifactorial model, a large sample size is needed. Therefore, the purposes of the current study were to assess the incidence of RRIs and to identify risk factors for the development of RRIs in a large group of runners participating in a running program for novice runners.

MATERIALS AND METHODS
Study design and participants
The present study is part of the NLstart2run study, a prospective cohort study on the health effects resulting from a 6-week “Start to Run” program [19]. All participants (N=7,660) who signed up for the “Start to Run” program in 2013 were informed about the NLstart2run study. The “Start to Run” program is a 6-week running course that is organized bi-annually (in March and September) by the Dutch Athletics Federation. All participants who entered
the study in March or September 2013 were followed prospectively during the 6-week running program.

All participants of the “Start to Run” program, aged between 18 and 65 were eligible for inclusion. Participants were included in the study after signing a digital informed consent and completing the baseline questionnaire. The study design, procedures and informed consent procedure were approved by the Medical Ethics Committee (no. 2012/350) of the University Medical Center Groningen (UMCG), the Netherlands. The study is registered in the Netherlands Trial Registry (NTR3676).

Running program

The running program aimed to prepare participants in 6 weeks for a 20-minute run without breaks. The running program advised two training sessions per week with an optional third session. A licensed athletics trainer supervised one training session, the other sessions had to be completed individually following a standardized training schedule. Each training session began with a warm-up and finished with a cool-down which both took approximately 15 minutes.

Baseline measurements

A baseline questionnaire was administered online one week before the start of the running program. This questionnaire covered demographics and other potential risk factors for RRI. These factors included: age, sex, calculated BMI (weight (kg) / height^2 (m)), waist-hip ratio (waist circumference (cm) / hip circumference (cm)). Textual instructions accompanied with two instructive pictures were shown to ensure the participants correctly measured waist and hip circumference. Previous running experience was assessed with a single question that asked whether participants were ever engaged in running on a regular basis. Also a single question concerning former lower extremity complaints that the participant attributed to running was used to assess self-reported previous running injuries. Other sports activities that were practiced on a regular basis in the past 12 months were assessed and, based on the type of sport, classified into sports with axial loading (e.g. volleyball, basketball or running) and sports without axial loading (e.g. swimming or cycling) [14]. Information about previous musculoskeletal complaints during sports and exercise that were not attributed to running was also obtained (yes/no answer). In a second question the self-assessed origin of these musculoskeletal complaints was asked, to separate sports injuries from other musculoskeletal complaints (i.e. complaints attributed to sports or not). Finally, participants had to provide information about type of running shoes (new versus used) and age of running shoes at start of the program.
Web-based training log during the 6-week running program

During the 6-week running program, at the end of each week, a training log was sent to the participants. This log asked for training characteristics in the preceding week. Weekly running frequency was obtained and running exposure (in minutes) was collected for each training session. In each training session was asked for the presence of pain to the lower extremity or lower back during or after running. If pain was present, anatomical locations were registered with a body chart. Pain was classified as running-related pain, when the subject attributed the pain to running. In a final question was asked if the entire training session could be completed, despite of the pain. When participants did not enter their digital training log after five days, an e-mail reminder was sent automatically. Participants were contacted by phone when the log was not completed one week after sending the reminder.

RRI registration

In the current study an RRI was defined as a musculoskeletal complaint of the lower extremity or back that the participant attributed to running and hampered running ability for three consecutive training sessions [14, 20]. Hampering of running could either be a reduction in running speed, distance or duration, or an inability to run, both as a result of running-related pain. RRI registration was based on the self-reported information in the running log. An RRI was registered when running ability was hampered for three consecutive training sessions as a result of pain at the same body part and the subject attributed that pain to running. In the running log participants were asked not to report muscle soreness and blisters in the pain registration.

Analyses

Participants were excluded from the analyses when no information was entered into the running log. Baseline characteristics for all potential risk factors were presented as means and standard deviations for continuous variables and in numbers and percentages for categorical variables. Running exposures were reported as medians with inter-quartile ranges (IQR). Both weekly and total incidence densities of RRIs were calculated as the number of RRIs per 1,000 hours of running exposure and the number of RRIs per 1,000 training sessions (i.e. athletic exposures). Hours of running exposure were measured from the start of the program until an RRI occurred or until the end of the program. Number of training sessions was measured as the sum of all training sessions until an RRI or until the end of the running program.

When baseline characteristics were missing, multiple imputation was used to include these cases into the complete case analysis and avoid bias due to missing values. Data were imputed using the MICE method implemented in SPSS (IBM SPSS statistics version 22) to create
10 multiple imputed datasets. Analyses were done on all datasets and results were averaged and adjusted for standard errors according to Rubin’s rule [21].

All potential risk factors were first univariately entered into a Cox regression analysis to examine the independent link of these variables to RRI. Subsequently, all these potential risk factors were entered into a multivariable Cox regression model following the Enter method. Minutes of running until RRI or until the end of the program, was considered the time scale for the Cox regression model. The event of interest was the occurrence of an RRI during the running program. For the categorical factors, the group with the lowest injury risk was chosen as reference. Hazard Ratios (HR) with corresponding 95% confidence intervals (CI) were reported. Possible risk factors with P ≤ 0.05 were considered statistical significant. The Cox regression analyses were conducted with R statistics (version 3.1.1) [22] using the R packages mice [23] and survival [24].

RESULTS
Participants
A total of 7,660 runners registered for the 2013 “Start to Run” program which was organized by the Dutch Athletics Federation. From these registrants, 1,936 expressed an interest to participate in the NLstart2run study. Among these participants, 30 fell outside the age range and 134 did not complete the baseline questionnaire, resulting in a study sample of 1,772 runners. Seventy six of the included participants (4.3%) were excluded from analyses, because no data were entered in the running log. The remaining 1,696 participants were included in the analyses. An overview of the participants flow can be found in Figure 1.

Baseline characteristics
For a number of participants, baseline information was missing for weight (0.1%), height (0.4%), waist and hip circumference (12.4%). Consequently, these data were imputed. The baseline characteristics of the participants who were included in the analyses are shown in table 1. The majority of participants were female (78.5%). Most participants (60.3%) did not have prior running experience and had never suffered from a previous RRI (82.7%). At baseline, 43.8% of the participants were engaged in other sports activities and 570 participants (33.6%) had a history of musculoskeletal complaints of which 278 (48.8%) were attributed to sports (i.e. sports injury).
The NLstart2run study: incidence and risk factors of running-related injuries in novice runners.

March 2013
4,400 registrants for the Start to Run program organized by the Dutch Athletics Federation.

September 2013
3,260 registrants for the Start to Run program organized by the Dutch Athletics Federation.

All participants who signed up for the NLstart2run study
N = 1,936

Excluded from inclusion
Under age 18: N = 11
Over age 65: N = 19
No baseline: N = 134

Included in study
N = 1,772

Excluded from analyses
No running log: N = 76

Included in analyses
N = 1,696

No running related injury
N = 1,511

Running related injury
N = 185

Figure 1: Flowchart of the participants included and excluded from the NLstart2run study.
Table 1: Baseline characteristics of the total population and both for the injured and non-injured participants. Categorical data was presented as N (%) and continuous data as means (SD).

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (N = 1696)</th>
<th>Non-injured (N = 1511)</th>
<th>Injured (N = 185)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>364 (21.5)</td>
<td>318 (21.0)</td>
<td>46 (24.9)</td>
</tr>
<tr>
<td>Female</td>
<td>1332 (78.5)</td>
<td>1193 (79.0)</td>
<td>139 (75.1)</td>
</tr>
<tr>
<td>Age (year)</td>
<td>43.3 (10.0)</td>
<td>43.1 (9.9)</td>
<td>45.1 (10.2)</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>25.5 (4.0)</td>
<td>25.4 (4.0)</td>
<td>26.2 (4.5)</td>
</tr>
<tr>
<td>Waist-hip ratio</td>
<td>0.91 (0.09)</td>
<td>0.91 (0.09)</td>
<td>0.91 (0.11)</td>
</tr>
<tr>
<td>Running experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1023 (60.3)</td>
<td>891 (59.0)</td>
<td>132 (71.4)</td>
</tr>
<tr>
<td>Yes, more than a year ago</td>
<td>460 (27.1)</td>
<td>421 (27.8)</td>
<td>39 (21.1)</td>
</tr>
<tr>
<td>Yes, less than a year ago</td>
<td>213 (12.6)</td>
<td>199 (13.2)</td>
<td>14 (7.6)</td>
</tr>
<tr>
<td>Previous RRI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1402 (82.7)</td>
<td>1243 (82.3)</td>
<td>159 (85.9)</td>
</tr>
<tr>
<td>Yes</td>
<td>294 (17.3)</td>
<td>268 (17.7)</td>
<td>26 (14.1)</td>
</tr>
<tr>
<td>Previous sports activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>953 (56.2)</td>
<td>849 (56.1)</td>
<td>104 (56.2)</td>
</tr>
<tr>
<td>Yes, with axial load</td>
<td>348 (20.5)</td>
<td>314 (20.8)</td>
<td>34 (18.4)</td>
</tr>
<tr>
<td>Yes, without axial load</td>
<td>395 (23.3)</td>
<td>348 (23.0)</td>
<td>47 (25.4)</td>
</tr>
<tr>
<td>Previous musculoskeletal complaints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1126 (66.4)</td>
<td>1020 (67.5)</td>
<td>106 (57.3)</td>
</tr>
<tr>
<td>Yes, not attributed to sports</td>
<td>292 (17.2)</td>
<td>245 (16.2)</td>
<td>47 (25.4)</td>
</tr>
<tr>
<td>Yes, attributed to sports</td>
<td>278 (16.4)</td>
<td>246 (16.3)</td>
<td>32 (17.3)</td>
</tr>
<tr>
<td>Running shoes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>957 (56.4)</td>
<td>843 (40.6)</td>
<td>59 (31.9)</td>
</tr>
<tr>
<td>Used</td>
<td>672 (39.6)</td>
<td>613 (55.8)</td>
<td>114 (61.6)</td>
</tr>
<tr>
<td>Other</td>
<td>67 (4.0)</td>
<td>55 (3.6)</td>
<td>12 (6.5)</td>
</tr>
<tr>
<td>Age of running shoes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 3 months</td>
<td>814 (48.0)</td>
<td>718 (47.5)</td>
<td>96 (51.9)</td>
</tr>
<tr>
<td>3 – 12 months</td>
<td>364 (21.5)</td>
<td>324 (21.4)</td>
<td>40 (21.6)</td>
</tr>
<tr>
<td>&gt; 12 months</td>
<td>518 (30.5)</td>
<td>469 (31.0)</td>
<td>49 (26.5)</td>
</tr>
</tbody>
</table>

Running exposure

Weekly running exposure ranged from a median of 25 minutes (IQR 27) in week 1 to 49 minutes (IQR 69) in week 5 (Table 2). The median running exposure during the entire running program was 227 minutes (IQR 162).
Table 2: Weekly running exposure in minutes [median with interquartile range (IQR)] and RRI incidence.

<table>
<thead>
<tr>
<th>Exposure (IQR)</th>
<th>RRIs (N)</th>
<th>Incidence (N/1000 h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>25.0 (27)</td>
<td>16</td>
</tr>
<tr>
<td>Week 2</td>
<td>32.0 (21)</td>
<td>56</td>
</tr>
<tr>
<td>Week 3</td>
<td>36.0 (30)</td>
<td>48</td>
</tr>
<tr>
<td>Week 4</td>
<td>41.0 (36)</td>
<td>39</td>
</tr>
<tr>
<td>Week 5</td>
<td>49.0 (69)</td>
<td>22</td>
</tr>
<tr>
<td>Week 6</td>
<td>38.0 (60)</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>227.0 (162)</td>
<td>185</td>
</tr>
</tbody>
</table>

RRI: Running-related injury

RRIIs during the program

During the running program, 185 participants (10.9%) developed an RRI. The estimated incidence densities are shown in Table 2 for each separate week of the running program. As shown in Table 2, most RRIIs were sustained during week 2 and 3 and the estimated incidence density was highest in week 2. The overall incidence density of RRIIs during the running program was 27.5 RRIIs per 1,000 hours of running or 9.9 RRIIs per 1,000 athletic exposures. Most RRIIs occurred at the knee (38.4%), followed by the calf (20%), Achilles tendon (13%) and shin (13%) (Figure 2).

![Figure 2: Anatomical distribution of RRIIs.](image-url)
Table 3: Results of the univariate and multivariable Cox regression analyses for overall RRIs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate analysis</th>
<th></th>
<th></th>
<th>Multivariable analysis</th>
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<th></th>
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<tr>
<td></td>
<td>HR</td>
<td>95% CI</td>
<td>P-value</td>
<td>HR</td>
<td>95% CI</td>
<td>P-value</td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.12</td>
<td>0.80 – 1.56</td>
<td>0.522</td>
<td>1.00</td>
<td>0.66 – 1.53</td>
<td>0.994</td>
</tr>
<tr>
<td>Age (year)</td>
<td>1.02</td>
<td>1.01 – 1.03</td>
<td>0.010</td>
<td>1.02</td>
<td>1.00 – 1.04</td>
<td>0.014</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>1.04</td>
<td>1.01 – 1.08</td>
<td>0.009</td>
<td>1.04</td>
<td>1.00 – 1.07</td>
<td>0.034</td>
</tr>
<tr>
<td>Waist-hip ratio</td>
<td>2.44</td>
<td>0.49 – 12.26</td>
<td>0.278</td>
<td>1.20</td>
<td>0.13 – 11.10</td>
<td>0.876</td>
</tr>
<tr>
<td>Running experience (ref = yes, less than a year ago)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No</td>
<td>2.13</td>
<td>1.23 – 3.69</td>
<td>0.007</td>
<td>2.38</td>
<td>1.24 – 4.57</td>
<td>0.009</td>
</tr>
<tr>
<td>Yes, more than a year ago</td>
<td>1.35</td>
<td>0.73 – 2.49</td>
<td>0.335</td>
<td>1.41</td>
<td>0.75 – 2.63</td>
<td>0.282</td>
</tr>
<tr>
<td>Previous RRI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.74</td>
<td>0.49 – 1.13</td>
<td>0.160</td>
<td>1.29</td>
<td>0.75 – 2.22</td>
<td>0.362</td>
</tr>
<tr>
<td>Sports activity (ref = yes, with axial load)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.14</td>
<td>0.77 – 1.68</td>
<td>0.514</td>
<td>1.18</td>
<td>0.80 – 1.74</td>
<td>0.417</td>
</tr>
<tr>
<td>Yes, without axial load</td>
<td>1.20</td>
<td>0.77 – 1.86</td>
<td>0.429</td>
<td>1.19</td>
<td>0.77 – 1.86</td>
<td>0.438</td>
</tr>
<tr>
<td>Previous musculoskeletal complaints (ref = no)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes, not attributed to sports</td>
<td>1.87</td>
<td>1.33 – 2.64</td>
<td>&lt;0.001</td>
<td>1.78</td>
<td>1.26 – 2.53</td>
<td>0.001</td>
</tr>
<tr>
<td>Yes, attributed to sports</td>
<td>1.24</td>
<td>0.83 – 1.84</td>
<td>0.294</td>
<td>1.19</td>
<td>0.80 – 1.77</td>
<td>0.400</td>
</tr>
<tr>
<td>Type of running shoes (ref = used)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>1.39</td>
<td>1.01 – 1.90</td>
<td>0.042</td>
<td>1.22</td>
<td>0.79 – 1.89</td>
<td>0.371</td>
</tr>
<tr>
<td>Other</td>
<td>2.22</td>
<td>1.19 – 4.13</td>
<td>0.012</td>
<td>1.84</td>
<td>0.96 – 3.52</td>
<td>0.064</td>
</tr>
<tr>
<td>Age of running shoes (ref = &lt; 3 months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – 12 months</td>
<td>0.90</td>
<td>0.62 – 1.31</td>
<td>0.585</td>
<td>1.24</td>
<td>0.80 – 1.90</td>
<td>0.337</td>
</tr>
<tr>
<td>&gt; 12 months</td>
<td>0.80</td>
<td>0.57 – 1.13</td>
<td>0.212</td>
<td>1.03</td>
<td>0.64 – 1.67</td>
<td>0.901</td>
</tr>
</tbody>
</table>
Risk factors for RRI

Results of the univariate and multivariable analyses are presented in Table 3. In the univariate analyses, age, BMI, no previous running experience, previous musculoskeletal complaints not attributed to sports and running shoes used were related to RRI. A higher age (HR 1.02; 95% CI 1.00-1.04), higher BMI (HR 1.04 95% CI 1.00-1.07), previous musculoskeletal complaints not attributed to sports (HR 1.78; 95% CI 1.26-2.53) and no previous running experience (HR 2.38; 95% CI 1.24-4.57) were also associated with the occurrence of RRI in the multivariable analysis.

DISCUSSION

The purpose of the current study was to examine the incidence of RRIs and risk factors for RRIs in runners following a 6-week “Start to Run” running program. During the running program, 185 runners (10.9%) sustained an RRI. Risk factors for RRIs were a higher age, a higher BMI, previous musculoskeletal complaints not attributed to sports and no previous running experience. In the current study, no significant association with RRI was found for gender, waist-hip ratio, previous RRI, previous sports injury, other sports activities and running shoes used during the program.

Incidence

Incidence rates in previous research among novice runners varied between 16.0% and 53.5% [8, 15, 20, 25]. Compared to these rates, the observed incidence rate of 10.9% in the current study is low. Large differences in RRI incidence are often attributed to variance in RRI definition [14]. A more strict RRI definition will result in a lower incidence rate. Nevertheless, RRI definitions in these previous studies were more or less the same to our definition in terms that these studies also registered an RRI when pain to the lower extremity or back caused a restriction of running for at least one week [8, 14, 15, 20, 25]. There were, however, differences in injury registration. In the current study RRIs were registered by the researchers, based on the information entered in the running logs. This method was similar to the method used by Buist et al. and Bredeweg et al. [8, 9, 18]. In contrast, other studies asked the participants to report an RRI to the researcher when an injury met the RRI definition [15, 25].

In addition to the injury definition, the follow-up period might also influence the incidence of RRIs. In this study the follow-up of 6 weeks was relatively short compared to follow-up periods of 8 to 13 weeks in other studies [8, 14, 25]. Naturally, more RRIs will be reported during a longer follow-up period. To compare RRI incidences between studies with different follow-up periods, RRI incidence can be expressed as an incidence density (e.g. the number of RRIs per 1,000 hours of running or per 1,000 athletic exposures). Unfortunately, most
studies do not report RRI incidence densities, presumably because running exposure until RRI or until the end of follow-up was not monitored. Previous studies that included incidence densities for novice runners reported values between 30 and 33 RRIs per 1,000 hours of running [9, 14, 20]. The incidence density of 27.5 observed in our study is slightly lower compared to previous studies among novice runners. However, RRI incidence in novice runners is substantially higher compared to incidence densities of 2.5 to 5.8 RRIs per 1,000 hours of running in more experienced runners [6]. Although other studies among novice runners did not report incidence densities per 1,000 athletic exposures, in the present study the RRI incidence density expressed per 1,000 training sessions was 9.9. This value is comparable to RRI incidence densities reported in cross-country runners [26-28].

Besides RRI definition, registration method and follow-up period, the lower incidence in the current study, compared to the RRI incidences in novice runners reported in other studies, may also be the result of the supervised training program, including the slow gradual increase of load.

Most injuries occurred at the knee (38.4%), followed by the calf, shin and Achilles tendon with respectively 20.0%, 13.0% and 13.0%. This is in line with previous research amongst novice runners in which most injuries were reported in the knee and lower leg [9, 25]. Therefore, despite the lower RRI incidence in more experienced runners, the anatomical distribution of RRIs is similar compared to novice runners [2, 29].

**Risk factors**

Previous injuries have shown to increase the risk of developing an RRI [29-33]. However, it is not always clear whether these previous injuries were related to running or other sports activities [9]. A recent study among novice runners showed that a previous RRI was not associated with the development of a new RRI, whereas a history of sports injuries was positively related to development of an RRI [15]. Therefore, the current study informed on the history of sports injuries as well as for musculoskeletal complaints during sports that were not attributed to sports (e.g. low back pain which was not caused by sports, but resulted in pain during sports). Only previous musculoskeletal complaints that were not attributed to sports increased the risk of developing an RRI and not previous sports injuries.

The increased RRI risk with previous musculoskeletal complaints during sports that were not attributed to sports might be explained by the high biomechanical load imposed by running [34]. Normally, the musculoskeletal system can adapt to high loads when sufficient recovery time is taken into account. When an optimal load is applied to the musculoskeletal system followed by sufficient recovery time, the strength of the system will increase [34]. Suffering from musculoskeletal complaints during sports might give an indication of a reduced loading capacity of the body, especially when the onset of these complaints is not attributed to
sports. It can be argued that the biomechanical load resulting from running is too high for these novice runners suffering from musculoskeletal complaints during sports and exercise, making them more prone to injury.

In this perspective, practicing sports with an axial load might be protective for developing an RRI, since this might have strengthened the musculoskeletal system and increased the loading capacity [35]. The results of the current study, however, did not support this hypothesis. In addition to a reduced loading capacity, previous musculoskeletal complaints might also have led to an altered movement pattern. This results in unequal loading of the body, which might increase injury susceptibility.

A lack of running experience increased the risk of sustaining an RRI. This finding is in line with other studies in which more running experience was related to a reduced RRI risk [30, 36]. Since the running program was aimed at novice runners, most participants were not involved in running on a regular basis before the start of the program. Therefore, running experience was not assessed as years of running experience as done in previous studies among recreational runners [30, 36], but classified into no, recent and former experience [9, 15]. Despite of this difference in classification, no running experience appears to be related to RRI in novice runners too. In more experienced runners, less running experience as risk-factor for RRI is most likely related to “the healthy runner effect”, whereby runners not suffering from injuries are more likely to persevere in running and consequently have more running experience [9, 37]. Novice runners, however, generally have little or no running experience, thus no history of severe RRIs. Therefore, the “healthy runner” phenomenon is probably not applicable to this group of runners. It can be speculated that the decreased RRI risk for novice runners with previous running experience can be explained by neuromuscular or musculoskeletal adaptations that could be the result of previous running activity, whereas absence of these adaptations might increase RRI risk.

In the present study, higher age was a risk factor for RRI. This finding is in line with Nielsen et al. who found a higher risk of RRI in novice runners aged 45 years and older [15]. In contrast, several studies found an inverse relationship between age and RRI risk, suggesting an increased RRI risk at lower ages [9, 32, 38]. The “healthy runner effect” might also explain these conflicting results concerning age as risk factor for RRI, indicating that extensive running experience is protective for RRI occurrence, independent of age. On the other hand, starting running at a higher age seems to be a risk-factor for RRI that might be attributed to age related changes of the musculoskeletal system [39].

Waist to hip ratio was not significantly related to the development of RRI. Higher BMI, however, was related to an increased RRI risk. This finding is in contrast to the results of a systematic review in long distance runners [29]. In this review, a BMI >26 kg/m2 was protective for the occurrence of RRI [29]. A recent study among 930 novice runners, however, showed
a trend that RRI risk increased with increasing BMI [15]. In previous research among novice runners, a higher BMI is often associated with RRI [9, 14, 40]. Based on the findings of the present study and the results of other studies among novice runners, a higher BMI is probably related to an increased risk of RRI in novice runners.

Limitations

The major strengths of this study are a prospective study design, the large cohort of almost 1,700 novice runners and the prescribed uniform running program. There were, however, several limitations as well. First, the baseline questionnaire that was used to administer potential risk-factors was based on self-reported information. This might have led to recall bias or under- or overestimation of predictor variables. It was tried to minimize these problems inherent to survey research by explaining that answers could not be right or wrong, making sure the questions were formulated clearly, adding informative pictures when applicable and splitting up difficult questions in multiple sub-questions. Second, registration of RRIs was also based on self-reported musculoskeletal complaints in the digital running log. Injured runners were not seen by a healthcare professional, thus, no diagnosis of the RRI was available. The registration of injuries in the current study was done using a body chart in combination with a short recall period to minimize the bias associated with self-reported injury information. Third, the cohort consisted mainly of female runners (78.5%), which may limit the generalizability of the results. Finally, with 6 weeks this running program had a relatively short duration. Previous studies in novice runners had longer follow-up periods ranging from 8 weeks to 1.5 year [5, 9, 14, 15]. This short duration may have led to the low number of RRIs and might not have been long enough to sustain severe overuse injuries. Still, for more than 70% of the injured runners in the present study, the registered RRI was a reason to quit running. This indicates the seriousness of these injuries even during a short-term running program and thereby the importance of preventing these RRIs.

Perspectives

The current study showed that the RRI incidence rate during a supervised 6-week “Start to Run” program was low compared to previous studies on novice runners. Incidence densities were, however, comparable or higher compared to more experienced runners. This highlights the necessity of effective prevention strategies. RRI incidence was highest during the first three weeks of a “Start to Run” program.

Risk factors for RRIs were a higher age, a higher BMI, previous musculoskeletal complaints during sports and exercise not attributed to sports and a lack of running experience. Not having previous running experience is the strongest risk factor for RRI followed by previous complaints during sports. Unfortunately these are non-modifiable risk factors. It is, there-
fore, of particular importance to identify runners who comply with these characteristics on
time. Subsequently, these runners can be informed about early signs of RRI. Secondly,
it is important that these runners are intensively guided during a running program, particu-
larly during the first three weeks. Therefore, future research should focus on possible det-
rimental training patterns for novice runners, especially for the vulnerable runners, which
might lead to new preventive measures.

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Chapter 4

The NLstart2run study: incidence and risk factors of running-related injuries in novice runners.