Previous injuries and some training characteristics predict running-related injuries in recreational runners: a prospective cohort study

Luiz Carlos Hespanhol Junior[1,2], Leonardo Oliveira Pena Costa[1,3] and Alexandre Dias Lopes[1]

[1]Master's and Doctoral Programs in Physical Therapy, [2]São Paulo Running Injury Group (SPRunIG), Universidade Cidade de São Paulo (UNICID), São Paulo, Brazil, [2]Department of Public & Occupational Health, EMGO+ Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands, [3]Musculoskeletal Division, The George Institute for Global Health, Sydney, Australia

Questions: What is the incidence of running-related injuries (RRIs) in recreational runners? Which personal and training characteristics predict RRIs in recreational runners? **Design**: Prospective cohort study. **Participants**: A total of 200 recreational runners answered a fortnightly online survey containing questions about their running routine, races, and presence of RRI. These runners were followed-up for a period of 12 weeks. **Outcome measures**: The primary outcome of this study was running-related injury. The incidence of injuries was calculated taking into account the exposure to running and was expressed by RRI/1000 hours. The association between potential predictive factors and RRIs was estimated using generalised estimating equation models. **Results**: A total of 84 RRIs were registered in 60 (31%) of the 191 recreational runners who completed all follow-up surveys. Of the injured runners 30% (n = 18/60) developed two or more RRIs, with 5/18 (28%) being recurrences. The incidence of RRI was 10 RRI/1000 hours of running exposure. The main type of RRI observed was muscle injuries (30%, n = 25/84). The knee was the most commonly affected anatomical region (19%, n = 16/84). The variables associated with RRI were: previous RRI (OR 1.88, 95% CI 1.01 to 3.51), duration of training although the effect was very small (OR 1.01, 95% CI 1.00 to 1.02), speed training (OR 1.46, 95% CI 1.02 to 2.10), and interval training (OR 0.61, 95% CI 0.43 to 0.88). **Conclusions**: Physiotherapists should be aware and advise runners that past RRI and speed training are associated with increased risk of further RRI, while interval training is associated with lower risk, although these associations may not be causative. **[Hespanhol Junior LC, Costa LOP, Lopes AD (2013) Previous injuries and some training characteristics predict running-related injuries in recreational runners: a prospective cohort study. *Journal of Physiotherapy* 59: 263–269]**

Key words: Athletic injuries, Epidemiology, Etiology, Follow-up studies, Incidence, Risk factors, Running, Sports

Introduction

Running is widely known to be beneficial for general health (Marti 1991, Williams 1997, Williams 2007, Williams 2008). However, one of the consequences of running is running-related injuries (RRI), with incidence rates ranging from 18.2% to 92.4% (Satterthwaite et al 1999, van Gent et al 2007, Van Middelkoop et al 2008a) or 6.8 to 59 injuries per 1000 hours of running exposure (Bovens et al 1989, Buist et al 2010, Lun et al 2004, Lysholm and Wiklander 1987, Rauh et al 2006, Wen et al 1998). This large variability may be explained by differences in the target populations investigated, such as recreational (Lun et al 2004) or ultra-marathon runners (Scheer and Murray 2011), and in the definitions of RRI used (Jacobs and Berson 1986, Lun et al 2004, Pileggi et al 2010, van Gent et al 2007).

Most runners run exclusively for fun and often complete just a few kilometres per training session. Some of them do not participate in running races at all. These recreational runners are probably the most common cohort within the running community. Few observational studies have investigated prospectively the incidence and risk factors of RRI in recreational runners who were not enrolled or not training to participate in races (Lun et al 2004, Macera et al 1989). The risk factors for RRI that have been identified in this population are: previous injuries, running more than 64 km/week, and less than three years of running experience (Macera et al 1989). We are unaware of prospective observational studies that controlled important aspects of training (duration of training sessions, speed training, and interval training) and the level of motivation to run in this population. Information about predictive factors for running injuries is essential for sports physiotherapists and other healthcare professionals for the development of prevention strategies for running injuries. Therefore the objectives of

What is already known on this topic: Running-related injuries are common and frequently cause absence from running. Studies among recreational runners have identified previous injuries, running more than 64 km/week, and less than 3 years of running experience as being associated with increased risk of running-related injury.

What this study adds: Over a 12-week period, 31% of recreational runners sustained a running-related injury severe enough to prevent participation in running for at least one usual training session. Predictors of increased injury risk included a previous running-related injury, higher duration of training (although the increase in risk was very small), and the use of speed training. The use of interval training was predictive of reduced injury risk.

this study were to determine the incidence of RRI in the lower limbs and spine in a sample of recreational runners, and to determine which training or personal characteristics may be considered predictive factors for RRI in this population.

Method

Study design

This is an observational injury surveillance study with a prospective cohort design that included 200 recreational runners who responded to an online survey with questions related to their running training routine, races and RRI. The recreational runners were followed-up for a period of 12 weeks, during which the online surveys were answered every two weeks.

Participants

To be included in the study, runners had to be at least 18 years old and to have been running for at least six months. Runners were excluded if they had either any medical restriction to running or any musculoskeletal injury that could preclude their participation in running training sessions.

Recruitment and baseline survey

A total of 4000 runners who were registered on the database of a running promoter were invited by email to participate in this study. This email provided information about the study procedures and contained a link to an electronic consent form. After agreeing to participate, the individuals were directed to a website that contained the baseline survey. The first 200 runners who agreed to participate in the study, met the inclusion criteria, and fully completed the baseline survey were included. This survey contained questions regarding personal characteristics, running routines, and previous RRI. Also a specific question was included to confirm that runners were injury-free before starting the follow-ups. All questions and details about the baseline survey are described in Appendix 1 (see eAddenda for Appendix 1) and were published elsewhere (Hespanhol Junior et al 2012).

Follow-up survey and outcome measures

Data collection consisted of six follow-up surveys (Appendix 2, see eAddenda for Appendix 2) sent to the runners by email every 14 days throughout the 12-week study period. Messages were sent by email every two weeks to remind the participants to complete the online survey for the previous fortnight. A reminder email was sent if the survey was not completed in three days. If runners had not completed the survey eight days after the initial email, they were then contacted by phone to remind them to complete the survey either online or over the phone. A reminder letter was sent by regular mail with a pre-paid return envelope if none of the previous reminder attempts was successful. Participants who received a reminder by regular mail could complete a printed survey that had the same questions as the online version. In order to minimise the recall bias in the information collected in these follow-up surveys, we sent all runners a running log by regular mail to help them to record each running session. We requested that participants complete the running log with all relevant information and transfer these data while completing the fortnightly follow-up survey.

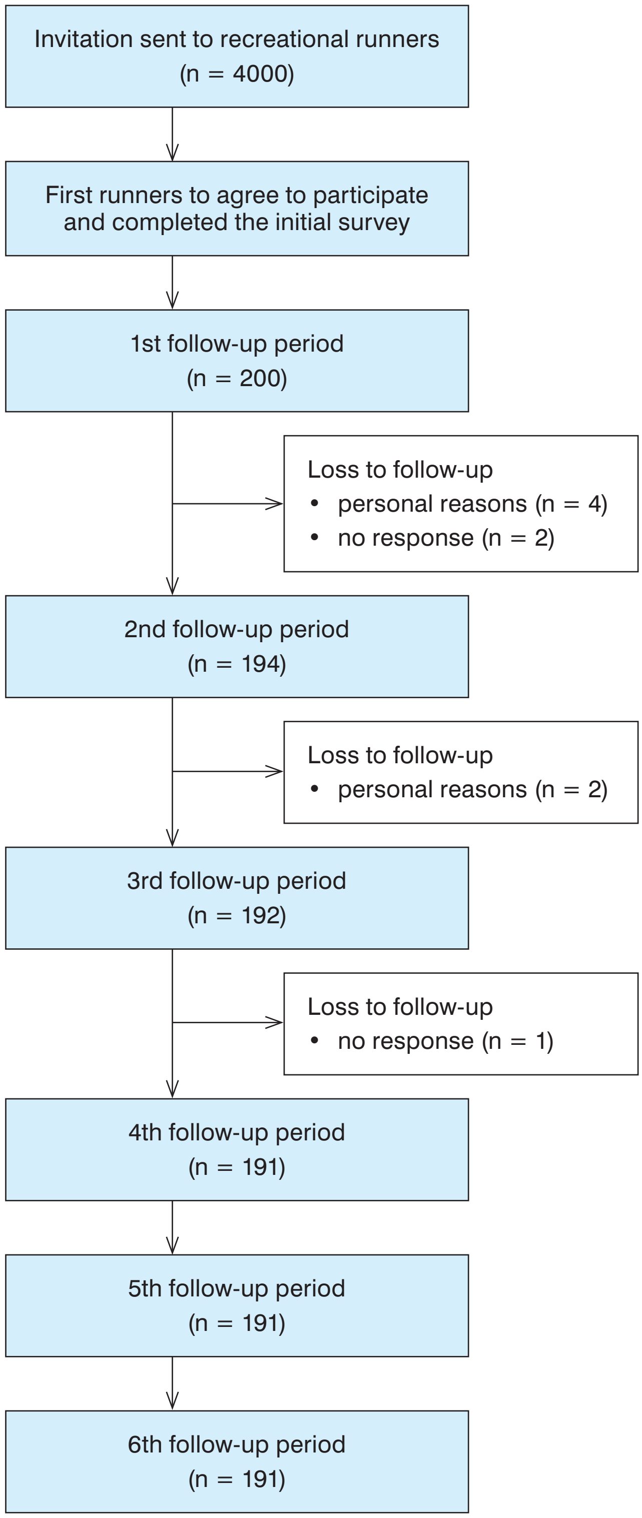

Figure 1. Flow of participants through the study.

The follow-up survey contained information about training, the presence of any RRI during the period, motivation to run, and any running races that the participant had competed in over the preceding two weeks. These questions elicited information about the following variables: number of times that the participant had trained; the total distance run (in kilometres); average time for each running session; predominant type of training surface (asphalt, cement, grass, dirt, sand, gravel); predominant type of terrain (flat course, uphill, downhill, or mixed); amount of speed

Table 1. Personal and training characteristics of participants.

Variable	All (n = 191)	Injured (n = 60)	Uninjured (n = 131)	*p*
Age *(yr)*, mean (SD)	42.8 (10.5)	41.8 (10.2)	42.9 (10.5)	0.249
Gender, n female (%)	50 (26)	11 (18)	39 (30)	0.095
Height *(cm)*, mean (SD)	171.1 (9.4)	172.4 (8.8)	170.5 (9.7)	0.196
Weight *(kg)*, mean (SD)	72.0 (14.0)	73.1 (11.8)	71.4 (14.9)	0.449
BMI, mean (SD)	24.4 (3.1)	24.5 (2.7)	24.4 (3.3)	0.825
Education, n (%)				
Elementary school	3 (2)	0 (0)	3 (2)	
High school	25 (13)	6 (10)	19 (15)	
University degree	82 (43)	27 (45)	55 (42)	
Postgraduate degree	81 (42)	27 (45)	54 (41)	0.525
Running experience *(yr)*, median (IQR)	5.0 (3.0 to 9.0)	4.0 (2.3 to 6.8)	5.0 (3.0 to 9.5)	0.066
Frequency *(sessions/wk)*, mean (SD)	3.0 (1.6)	1.9 (1.5)	3.2 (1.5)	< 0.001
Distance *(km/wk)*, median (IQR)	28.5 (15.0 to 41.0)	15 (2.5 to 26.3)	30 (18.0 to 42.5)	< 0.001
Duration *(min/session)*, median (IQR)	60 (50 to 80)	50 (15 to 60)	60 (50 to 90)	< 0.001
Surface				
Hard *(times/wk)*[a], median (IQR)	1.5 (0.5 to 3.0)	0.5 (0.0 to 2.0)	1.5 (0.5 to 3.0)	< 0.001
Soft *(times/wk)*[b], median (IQR)	0.0 (0.0 to 0.5)	0.0 (0.0 to 0.0)	0.0 (0.0 to 1.0)	< 0.001
Treadmill *(times/wk)*, median (IQR)	0.0 (0.0 to 0.5)	0.0 (0.0 to 1.0)	0.0 (0.0 to 1.5)	0.071
Other *(times/wk)*[c], median (IQR)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.087
Terrain				
Flat *(times/wk)*, median (IQR)	2.0 (0.5 to 3.0)	1.0 (0.0 to 2.0)	2.0 (1.0 to 3.0)	< 0.001
Uphill *(times/wk)*, median (IQR)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.5)	0.001
Downhill *(times/wk)*, median (IQR)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.5)	0.0 (0.0 to 0.0)	0.186
Mixed *(times/wk)*[d], median (IQR)	0.5 (0.0 to 1.0)	0.0 (0.0 to 0.5)	0.5 (0.0 to 1.5)	< 0.001
Training				
Speed *(times/wk)*, median (IQR)	0.0 (0.0 to 1.0)	0.0 (0.0 to 0.5)	0.0 (0.0 to 1.0)	0.213
Interval *(times/wk)*, median (IQR)	0.0 (0.0 to 1.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 1.0)	<0.001
Missed training				
Personal reasons *(n/wk)*, median (IQR)	0.0 (0.0 to 1.0)	0.0 (0.0 to 1.5)	0.0 (0.0 to 1.0)	0.366
Lack of motivation *(n/wk)*, median (IQR)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.308
Unfavourable weather *(n/wk)*, median (IQR)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.0 (0.0 to 0.0)	0.185
How do you feel? n (%)				
Motivated (majority of 6 follow-ups)	138 (72)	37 (62)	101 (77)	
Neutral (majority of 6 follow-ups)	21 (11)	9 (15)	12 (9)	
Poorly motivated (majority of 6 follow-ups)	15 (8)	7 (12)	8 (6)	
Draw between any category (6 follow-ups)	17 (9)	7 (12)	10 (8)	0.171
Training monitoring, n (%)				
Coaches	79 (41)	23 (38)	56 (43)	
Web spreadsheets	19 (10)	5 (8)	14 (11)	
No training plan	93 (49)	32 (53)	61 (47)	0.667
Participated in a race during the study, n (%)				
Yes (at least 1 race)	174 (91)	54 (90)	120 (92)	
No (no participation during all the study)	17 (9)	6 (10)	11 (8)	0.718
Previous running-related injury, n (%)				
None	90 (47)	26 (43)	64 (49)	
1	53 (28)	15 (25)	38 (29)	
2	39 (20)	15 (25)	24 (18)	
3	9 (5)	4 (7)	5 (4)	0.549

SD = standard deviation, IQR = interquartile range, BMI = body mass index. [a]Hard surface = asphalt and cement. [b]Soft surface = dirt, grass and gravel. [c]Other surface = sand and synthetic. [d]Mixed terrain = uphill and downhill

Table 2. The 84 running-related injuries by type and anatomical location.

Characteristic of RRI	n (%)	Duration of RRI in wks mean (SD)	Lost training sessions/wk mean (SD)	Pain intensity mean (SD)
Type				
Muscle strain/rupture/tear	25 (30)	3.6 (2.7)	4.3 (2.9)	5.8 (2.0)
Low back pain	12 (14)	2.4 (0.8)	1.6 (1.0)	5.2 (2.5)
Tendinopathy	10 (12)	4.0 (2.1)	2.8 (2.0)	6.0 (2.0)
Plantar fasciitis	7 (8)	4.7 (3.5)	5.7 (5.5)	5.8 (2.5)
Meniscal or cartilage damage	6 (7)	3.2 (1.8)	4.0 (5.0)	3.6 (2.4)
Contusion/haematoma/ecchymosis	4 (5)	2.5 (1.0)	4.6 (2.3)	6.4 (1.8)
Intense spasm or severe cramp	3 (4)	2.0 (0.0)	3.8 (4.2)	4.8 (2.2)
Sprain (injury of the joint and/or ligaments)	2 (2)	3.0 (1.4)	3.3 (2.3)	3.7 (0.6)
Stress fracture (overload)	2 (2)	4.0 (0.0)	3.8 (4.2)	7.8 (1.5)
Arthritis/synovitis/bursitis	1 (1)	2.0[a]	2.0[a]	9.0[a]
Dislocation, subluxation	1 (1)	2.0[a]	3.0[a]	3.0[a]
Patellar chondromalacia	1 (1)	12.0[a]	3.7 (1.4)	8.7 (0.8)
Not identified	10 (12)	3.3 (1.8)	4.4 (3.3)	3.9 (2.2)
Anatomical location				
Knee	16 (19)	4.3 (3.0)	4.2 (3.3)	4.9 (2.7)
Foot/toes	14 (17)	3.7 (2.7)	4.5 (4.4)	5.6 (2.4)
Leg	12 (14)	4.0 (3.1)	3.9 (2.1)	5.5 (2.2)
Lumbar spine	12 (14)	2.5 (0.9)	1.8 (1.0)	5.6 (2.4)
Thigh	12 (14)	2.5 (1.2)	3.4 (3.1)	5.9 (1.9)
Ankle	6 (7)	2.7 (1.0)	2.4 (1.8)	5.3 (2.6)
Hip/groin	5 (6)	4.0 (3.5)	6.8 (4.0)	7.3 (1.4)
Achilles tendon (calcaneal)	3 (4)	4.7 (1.2)	1.7 (1.7)	6.1 (2.1)
Cervical spine	2 (2)	3.0 (1.4)	4.3 (4.2)	4.7 (3.1)
Pelvis/sacrum/buttocks	2 (2)	7.0 (4.2)	4.6 (1.1)	5.4 (1.5)

RRI = running-related injury. [a]Absolute numbers

training (ie, training sessions that include some bouts of high speed running during a very short period); number of interval training sessions as different running intensities (ie, Fartlek); motivation during training (motivated, neutral, or poorly motivated); amount and type of running races performed; and absence of training due to personal reasons, motivation, or unfavourable weather conditions (eg, rain). Participants were also asked whether they failed to train for at least one session due to the presence of any RRI during the period (see Question 12 in Appendix 2 on the eAddenda for details). In this case, the participant was asked to report the symptoms/diagnosis and the anatomical region that was injured, as well as to rate the pain intensity using a 10-point (1–10) pain numerical rating scale.

The primary outcome of this study was the incidence of RRI. The definition of RRI used was 'any pain of musculoskeletal origin attributed to running by the runners themselves and severe enough to prevent the runner from performing at least one training session' (Bovens et al 1989, Macera et al 1989, van Middelkoop et al 2007, Van Middelkoop et al 2008b). Recurrent RRI during the 12-week follow-up period was defined, based on previous studies, as an RRI of the same type and at the same site as the index injury and which occurred after the runner returned to full participation in running sessions after the index injury (Fuller et al 2006, Fuller et al 2007). The index injury in this study was classified as the first RRI developed by the runners during the 12-week follow-up.

Data analysis

Our sample size was estimated using an anticipated RRI incidence of 26% in the population based upon a previous study (Buist et al 2010), with an estimation accuracy of 25% and a significance level of 5%. This analysis suggested a sample of at least 175 runners. Expecting a loss of follow up of approximately 10–15%, we decided to recruit a sample of 200 runners. Descriptive statistics were used to present the characteristics of the participants. Chi-square, Mann-Whitney, and Student's t-tests were performed to check differences between those who developed RRI during the 12-week follow-up and those who did not. The distribution of the data was checked by visual inspection of histograms.

The incidence of RRI was calculated as the percentage of injured runners and as RRIs per 1000 hours of exposure to running. The exposure to running was calculated using the exposure time from the beginning of the study until the end of follow-up (12 weeks). To determine possible associations between training characteristics and RRI, we initially performed a univariate analysis using the generalised estimating equations (GEE) for each independent variable with RRI as the dependent variable. The variables that had significant associations with $p < 0.20$ in the univariate

Table 3. Univariate binary logistic analysis using generalised estimating equations.

Variable	Odds ratio (95% CI)	*p*
Running experience *(yr)*	0.99 (0.94 to 1.03)	0.601
Frequency (sessions/week)	1.01 (0.87 to 1.18)	0.856
Distance *(km/week)*	1.00 (0.99 to 1.01)	0.920
Duration (min/session)[a]	1.01 (1.00 to 1.02)	0.017
Type of surface *(times/week)*		
Hard[b]	1.14 (0.99 to 1.32)	0.074
Soft[c]	0.89 (0.71 to 1.11)	0.287
Treadmill	1.03 (0.87 to 1.21)	0.745
Other[d]	0.23 (0.04 to 1.25)	0.088
Type of terrain *(times/week)*		
Flat	0.97 (0.81 to 1.17)	0.773
Uphill	0.53 (0.26 to 1.08)	0.081
Downhill	0.09 (0.004 to 2.08)	0.133
Mixed[e]	1.00 (0.82 to 1.22)	1.000
Type of training *(times/week)*		
Speed training	1.25 (0.93 to 1.67)	0.134
Interval training	0.71 (0.48 to 1.03)	0.061
How do you feel?		
Motivated	1	–
Neutral	1.22 (0.64 to 2.32)	0.554
Poorly motivated	0.89 (0.35 to 2.25)	0.808
Participated in a race during the study		
No	1	–
Yes	0.79 (0.49 to 1.28)	0.331
Previous RRI		
No	1	–
Yes	2.21 (1.22 to 4.01)	0.009

CI = confidence interval, RRI = runing-related injury. [a]The odds ratio indicates the change in odds for a 10-units increase. [b]Asphalt and cement. [c]Dirt, grass and gravel. [d]Sand and synthetic. [e]Uphill and downhill

analysis were selected for inclusion in the multivariate binary logistic analysis to control for confounders using GEE. The GEE was described as an appropriate method to analyse longitudinal data with recurrent events (Twisk et al 2005). As we collected the RRI information fortnightly, we used predictors from the preceding 14 days to predict RRI occurring in a given fortnight to be sure that the predictors were related to period before the RRI occurred. The results were expressed as odds ratios (OR) and 95% CI. For continuous variables the ORs indicate the change in odds for a one-unit increase, except for duration of training, which indicates the change in odds for a 10-unit increase. Predictive factors were classified as follows: risk factors for RRI if the 95% CI around the OR was greater than 1.0, or protective factors for RRI if the 95% CI around the OR was lower than 1.0.

Table 4. Multivariate binary logistic analysis using generalised estimating equation.

Variable	Odds ratio (95% CI)	*p*
Duration (min/session)[a]	1.01 (1.00 to 1.02)	0.008
Type of surface *(times/week)*		
Hard[b]	1.06 (0.86 to 1.31)	0.588
Other[c]	0.25 (0.05 to 1.25)	0.092
Type of terrain *(times/week)*		
Uphill	0.65 (0.38 to 1.13)	0.126
Downhill	0.12 (0.01 to 1.75)	0.122
Type of training *(times/week)*		
Speed training	1.46 (1.02 to 2.10)	0.039
Interval training	0.61 (0.43 to 0.88)	0.008
Previous RRI		
No	1	–
Yes	1.88 (1.01 to 3.51)	0.046

CI = confidence interval, RRI = running-related injury. [a]The odds ratio indicates the change in odds for a 10-units increase. [b]Asphalt and cement. [c]Sand and synthetic

Results

Flow of participants through the study

Of the 200 runners who were enrolled in the study, 191 answered all six questionnaires corresponding to the 12 weeks of follow-up (96%) as presented in Figure 1. The characteristics of the recreational runners are presented in Table 1.

Incidence of RRI

During the 12-week follow-up, 84 RRIs were registered by 60 (31%) of the 191 recreational runners analysed. The incidence of RRI in this 12-week follow-up was 10 RRIs per 1000 hours of running exposure. Of the injured runners, 70% (42/60) developed one RRI, 22% (13/60) developed two injuries, 7% (4/60) developed three injuries, and 2% (1/60) developed four injuries. Of the runners that presented two or more RRIs in this study, 28% (5/18) represented recurrences. The mean duration of the RRIs registered in this study was 3.4 weeks (SD 2.3), an average of 3.9 running sessions per runner (SD 3.3) were missed due to RRIs, and the mean pain intensity of these injuries was 5.6 points (SD 2.3) on a 10-point scale. The type of RRI and anatomic region results are fully described in Table 2.

Predictive factors for RRI

Table 3 describes the results of the univariate GEE analysis. The variables with a $p < 0.20$ in this analysis were included in the multivariate GEE analysis, which is presented in Table 4. The training characteristics that were identified as risk factors for RRI in the final model were: previous RRI (OR 1.88, 95% CI 1.01 to 3.51), duration of training session (OR 1.01, 95% CI 1.00 to 1.02), and speed training (OR 1.46, 95% CI 1.02 to 2.10). Interval training was identified as the protective factor against the development of RRIs (OR 0.61, 95% CI 0.43 to 0.88).

Discussion

The results of this study are relevant because they provide new information about the incidence of RRIs and modifiable predictive factors for RRI in recreational runners. The identification of the RRI incidence in recreational runners is important to monitor interventions that can influence the rate of RRI in this population. In addition, the identification of modifiable risk factors is important because this may lead to modifications in the injury risk profile and the information can be used in the development of preventive interventions.

The incidence of RRI found in this study (31%) was lower than those previously reported: 79% at six months follow-up (Lun et al 2004) and 51% at 12 months follow-up (Macera et al 1989) in recreational runners not enrolled or training to participate in races. This may be explained by these previous studies using longer follow-up and different RRI definitions. While these previous studies considered a reduction of the running volume due to injury enough to define a RRI (Lun et al 2004, Macera et al 1989), our study used a more rigorous criterion (ie, missing at least one training session due to RRI). Despite this, these results are worrying because the incidence of RRI in recreational runners may increase from 31% in three months (as we found in this study) to 51% in one year (Macera et al 1989). These high RRI rates are likely to decrease running adherence leading to a negative influence in an active lifestyle and increasing the costs of health care.

We found that previous RRI was associated with higher risk of RRI in recreational runners. A systematic review on this topic concluded that this variable had strong evidence to be a risk factor of RRI (van Gent et al 2007). Two possible explanations for these findings are: the 'new' injury is an exacerbation of an earlier injury that was not completely recovered (Taunton et al 2003, Wen et al 1998); and injured runners may adopt a different biomechanical pattern in order to protect the injured anatomical region and this could predispose them to a new injury.

Duration of training, speed training, and interval training were also associated with higher RRI. Despite statistical significance, the OR of duration of training was very small indicating an irrelevant effect in real life. This means that in our study and in recreational runners generally, other training characteristics can be more important to predict RRI. Speed training was associated with higher RRI. This can be explained by an increase in the running intensity overloading the musculoskeletal structures, predisposing recreational runners to injury. The fact that interval training was associated with lower RRI in this study also supports this hypothesis. Most of the recreational runners who perform interval training switch from normal or slightly higher intensity intervals to lower or much lower intensity intervals (eg, walking), resulting in a lower total training intensity in a given running session, decreasing the odds of injury.

We consider that the strengths of this study are two-fold. First, we measured some training variables (duration of training session, speed training, interval training, and the level of motivation to run) that were not measured in previous observational prospective studies with recreational runners not enrolled or training to participate in races. Therefore, our results add important information about the association between training variables with RRI in recreational runners. Second, we performed a statistical analysis to determine the predictive factors of RRI that take into account the recurrent events and the variation of the time-dependent variables during the study. To our knowledge, no studies with the purpose of identifying predictive factors of RRI have used this longitudinal statistical technique.

There are some limitations to this study. First, the recreational runners who participated in this study were recruited from the same database, which may limit the generalisability of our results. Second, self-report injuries were used in the study. The logistics of this study did not allow for confirmation of diagnosis by a health professional. Therefore, to facilitate injury reporting participants were required to select options from drop-down boxes with the additional option of entering a response to an empty box if there was no suitable option in the drop-down boxes. Third, this study had a relatively short follow-up period (ie, 12 weeks). We suggest conducting further prospective studies with longer follow-up periods and with more accurate diagnosis.

In conclusion, this prospective cohort study demonstrated that the incidence of RRI in recreational runners was 31% or 10 RRIs per 1000 hours of running exposure. The most frequent type of injury was muscle injury and the most affected anatomical region was the knee. The relevant risk factors for RRI in recreational runners were identified in this study as previous RRI and speed training, while the protective factor identified was interval training. ■

eAddenda: Appendix 1 and 2 available at jop.physiotherapy.asn.au

Ethics: The Ethics Committee of the Universidade Cidade de São Paulo approved this study (number 13506607). All participants gave written informed consent before data collection began.

Competing interests: None declared.

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Correspondence: Luiz Carlos Hespanhol Junior, Department of Public & Occupational Health, VU University Medical Center, The Netherlands. Email: luca_hespanhol@hotmail.com

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