Epidemiology and etiology of lower limb injuries in Iranian recreational runners

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Abstract

Background Knowledge about prevalence and etiology of running-related injuries (RRIs) is important to tailor an effective RRI prevention program. We aimed to investigate the prevalence and etiology of RRIs in Iranian recreational runners.

Methods An internet-based self-developed questionnaire was sent to recreational runners recruited through social media. The questionnaire asked about personal and training characteristics, psychological factors (passion, BERQ-2, RAND-36), SQUASH, sleep, foot type and RRIs over the last six months. Data were analyzed descriptively and using logistic regression.

Results Self-reported data from 804 questionnaires were analyzed. Twenty-five potential risk factors for RRIs were investigated. The male-to-female proportion was 57.5:42.5. 54% of runners reported at least one RRI. Patellofemoral pain syndrome was the most-reported injury (19.8%), followed by medial tibial stress syndrome (16.9%). Knee was the most-affected location (44.6%), followed by lower leg (19.2%). The variables associated with RRIs were: overweight (odds ratio (OR):1.77), pes planus (OR:1.81), running over 20 km/week (OR:1.62), hard-surface running (OR:1.38), running company (OR:1.74), following a training program (OR:1.50), obsessive passionate attitude (OR:1.05), RAND-36 (OR:0.96), and sleep quality (OR:1.46). Associated factors for all different RRI types were analyzed too.

Conclusions Overweight, running over 20 km/week, hard-surface running, having pes planus or cavus, higher obsessive passion, lower RAND-36, and poor sleep quality were the most predictive risk factors for RRIs types. This study highlighted the importance of psychological factors besides abnormal foot arch and some training-related risk factors for RRIs in Iranian runners. These results may be useful for runners and coaches to tailor effective training programs and to design RRI prevention programs that may help clinicians when managing RRIs.

1. Introduction

Running has become the most popular physical activity [1]. Thanks to its affordability and convenience, needing less equipment than many other sports, the number of runners has increased in recent decades [2]. Regular, leisure-time running is considered recreational. Running has many benefits, like improvement of mental and physical health: a study reported a 45% lower risk of cardiovascular mortality in runners compared to non-runners [3].

In Iran too, recreational running has become more popular because people have found it an easy and accessible way to stay healthy. This is important for Iranians ever since a recently published review about cardiovascular disease in Iran reported insufficient physical activity as one of the leading causes of the high prevalence of cardiovascular disease [4].

A major drawback of running is that it is accompanied by running-related injuries (RRIs), with incidence rates varying from 19.4% to 79%, depending on the definition used and the population studied [5].

To develop preventive measures for RRI, more knowledge about etiologic factors is needed. According to the Translating Research into Injury Prevention Practice framework (TRIIPP) [6], upon injury surveillance the second

stage is establishing the etiology of injury. Accordingly, identifying and understanding causal factors for RRIs as well as the most commonly affected anatomical locations are important steps toward developing an effective prevention program [7]. There is evidence that the etiology of RRI is multifactorial and includes both extrinsic and intrinsic risk factors, some modifiable [8]. Several studies have reported risk factors predisposing runners to injuries [8–11], including abnormal biomechanics, previous injuries, training-related risk factors and insufficient running experience. However, there is still no consensus on the exact etiology of RRIs and there might even be differences between populations from different countries, regions or cultures.

Besides running/training and personal factors, RRIs may also be impacted by health, psychological, and lifestyle factors. These factors have not been explored extensively in runners yet, and not enough information on their effects on RRIs (and vice versa) is available. Recent reviews emphasize the importance of psychological factors for sports injuries [12, 13], indicating that alterations in stress can predict sports injury incidence. A study has also been designed to investigate the effect of mental aspects on RRIs [14].

Recreational runners comprise the largest group of runners worldwide [15]; according to a recent systematic review, a minority of studies investigating RRIs involve recreational runners [16]. Studies mostly target runners participating in running events or organized running groups which cannot be a real-life representation of recreational runners. In Iran, recreational runners run mostly individually or in small groups. Many of them, especially women, prefer running on treadmills in indoor gyms due to religious and general beliefs.

RRIs may also have negative psychological and physical effects, and may cause individuals to quit sports or/and physical activities temporarily or even permanently [17]. RRIs can additionally result in high treatment costs and costs related to work absenteeism, which can lead to discontinuing running or reducing individual motivation [18]. Hence the need for investigating epidemiology and etiology of RRIs specifically in Iranian recreational runners is warranted.

Although several studies addressed risk factors in a small sample size of recreational runners in Iran [19–21], information about epidemiology and etiology of RRIs in Iranian recreational runners is still lacking. As the knowledge of prevalence and etiology of RRIs is the first step to effectively tailor RRI preventive programs, the aim of the current study is to describe the epidemiology, etiology and impact of RRIs among Iranian recreational runners.

2. Methods

2.1 Study design

This is a cross-sectional survey investigating the prevalence, risk factors and psychological impact of running-related injuries in Iranian runners using an electronic/web-based questionnaire. Ethical approval for this study was obtained from the Tehran university institutional review board (IR.SSRI. 1398.154).

2.2 Participants

Recreational runners were invited to participate through social media and by contacting them at sports and health departments in universities, running clubs, gyms, and sports shops in Tehran, Mashhad, and Shiraz.

Because of their geographical differences, these cities can be considered most representative of the Iranian runners' population. A recreational runner was defined as someone who has been running for at least 9 months prior to completing the questionnaire with a minimum of 5 km/week and not classified as an elite runner by track and field federation. Eligibility as a recreational runner was first confirmed by a running club manager (either a university or public running club) or one of the researchers.

2.3 Data collection

A specific questionnaire in Farsi, tailored with the help of the "Start to Run" study questionnaire [22], with questions on personal characteristics, medical information, running characteristics, running-related injuries, and questionnaires of passion scale, RAND 36-items, BERQ-2 and SQUASH was developed using Google Form. This questionnaire was pilot-tested in 12 runners with varying running experience, after which some changes were made to arrive at the final questionnaire.

An electronic link to the online questionnaire was sent to each eligible runner. Runners were advised to consult their physicians or physiotherapists about their foot type and possible previous RRIs.

The first section of the questionnaire included eligibility criteria, instructions for completing the questionnaire, and a consent form. Upon confirming the first section, the runner could proceed with the questionnaire. The questionnaire inquired about personal characteristics, general medical information, running profiles (including running experience, weekly running distance, speed, weekly frequency, foot arch type, foot strike type, running surface, running shoes), history of RRIs over the past six months (injuries included patellofemoral pain, medial tibial stress syndrome, Achilles tendinopathy, patellar tendinopathy, iliotibial band syndrome, plantar fasciitis, strain, sprain, and meniscal or cartilage injury), and injury location. To determine injury location, a manikin chart divided into 8 major locations and 22 sub-locations was designed. The main questionnaire also included these questionnaires: obsessive passion scale; BERQ-2, assessing motivation to exercise; RAND 36-items, assessing perceived health; and SQUASH, assessing physical activity in daily life.

According to the consensus definition of RRI [23], an RRI was defined as "Running-related (training or competition) musculoskeletal pain in the lower limbs that causes a restriction on or stoppage of running (distance, speed, duration, or training) for at least 7 days or 3 consecutive scheduled training sessions, or that requires the runner to consult a physician or other health professional."

2.4 Data analysis

Participants' characteristics are presented in Table 1 using descriptive statistics. Mann-Whitney and Chi-square tests were used to compare data between runners with and without any history of RRIs. Since no quantitative variables were distributed normally, data were reported as median and interquartile range; categorical variables were reported as frequency and percentages. A univariate logistic regression analysis was used to assess a likely association between the risk factors and having RRI. Those variables with a $p < 0.20$ were included in the multivariate logistic regression model [15] with backward elimination, whereby variables remained in the model if their associated multivariate p -value < 0.05 . Only modifiable factors were entered into multivariate logistic regression, therefore sex and age were not entered into multivariate logistic models. To establish the

assumption of no multicollinearity among the independent variables and enhance model fitting, the high correlated variables (obsessive passion and BERQ-2 scores ($r=0.81$, $p<0.001$) were not entered together into the multivariate logistic analysis. In such cases, either variable having a lower univariate p-value was entered into the multivariate logistic analysis. We reported the results as odds ratios (OR) and 95%CI (confidence interval). The OR in continuous variables represents the change in odds of injury for a one-unit increase. The OR in categorical variables represents the change in odds of injury relative to referenced category determined in Table 3. Sleep quality was rated as very good (1), good (2), medium (3), poor (4), and very poor (5). The OR in sleep quality represents the change in odds of injury for a one-rank increase in sleep rating. Factors were considered risk factors if $OR>1$ and protective factors if $OR<1$.

3. Results

3.1 Participants

The questionnaire was filled out by 826 runners, 22 of them excluded due to missing or incorrect data. Total data from 804 questionnaires were analyzed – 644 from Tehran city, 102 from Mashhad, and 58 from Shiraz city.

3.2 Descriptive data

Table 1 shows the description of participants’ characteristics divided into two groups, with/without injury history. Male runners comprise 57.5% (462) of participants, female runners 42.5% (342); 80% of runners reported a BMI in the healthy range ($18<BMI<25$); 80% had <5 years of running experience; 59% and 70% had a running duration of up to 60 min/session and up to 3 sessions/week, respectively; 80% reported also participating in other sports. Most runners reported performing warm-up (92%) and cool-down (84%) exercises.

Table 1: Participants’ characteristics

3.3 Running injuries and location

Table 2A shows the epidemiology of RRI. Of the 804 runners, 432 (54%) reported at least one RRI over the last six months; 74 reported multiple injuries (74 reported two injuries, 10 reported three injuries); 55% (256) of male runners and 51% (176) of female runners reported at least one RRI. Participants reported that about 89% of self-reported injuries were diagnosed by either

a physician or a physiotherapist. In total, 516 RRIs were reported. Patellofemoral pain syndrome (PFPS) was the most-reported injury (19.8%), followed by medial tibial stress syndrome (MTSS) (16.9%). Table 2B shows the anatomical sites of RRIs. The knee (44%) was the most frequently reported injury location, followed by the lower leg (19.9). Tables S1 and S2 (additional file) describe running injury type and location by gender .

Table 2: Running-related injury types* and injury location

A. Running-related injury		B. Location of injury	
Injury	Total n (%*)	Location	Total n (%)
PFPS	102 (19.8)	Knee	230 (44.6)
MTSS	87 (16.9)	Lower leg	99 (19.2)
Thigh strain	45 (8.7)	Foot/toe	48 (9.3)
Meniscus or cartilage injury	42 (8.1)	Ankle	36 (7.0)
ITBS	36 (7.0)	Achilles	36 (7.0)
AT	36 (7.0)	Hip/groin/buttock	29 (5.6)
Ankle sprain	35 (6.8)	Thigh	23 (4.5)
PF	28 (5.4)	Lower back	15 (2.9)
PT	20 (3.9)		
Knee sprain	12 (2.3)		
Calf strain	11 (2.1)		
Others	62 (12.0)		

* Proportion of any RRI in total RRIs.

Abbreviations: PFPS patellofemoral pain syndrome. MTSS medial tibial stress syndrome, ITBS iliotibial band syndrome, AT Achilles tendon injury, PF plantar fasciitis, PT patellar tendinopathy

3.4 Running injuries and associated factors

Table 3 shows the results of univariate logistic regression analysis between runners with and without history of injury, with each factor analyzed separately. Being overweight, running over 20 km/week and 60 min/session, performing other sports, running on hard surfaces, pes planus or cavus, a higher obsessive passion for running, and lower perceived health are the factors significantly associated with injuries ($p < 0.05$).

Table 3: Results of univariate logistic regression analysis, injury versus injury-free runners

Table 4 shows the results of multivariate logistic regression analysis of risk factors associated with each injury type. Results of multivariate logistic regression analysis for calf strain and knee sprain were reported in the additional file, table S3. Associated factors for injury were: **overweight** (OR 1.89, 95%CI 1.24-2.88), **running over 20 km/week** (OR 1.52, 95%CI 1.01-2.29), **running company** (OR 1.68, 95%CI 1.19-2.38), **following a training program** (OR 1.50, 95%CI 1.08-2.07), **hard surface** (OR 1.37, 95%CI 1.18-1.59), **pes planus** (OR 1.85, 95%CI 1.17-2.94), **sleep quality** (OR 1.48, 95%CI 1.22-1.80), **obsessive passion** (OR 1.05, 95%CI 1.03-1.07), and **RAND-36** (OR 0.96, 95%CI 0.95-0.98).

3.5 Association between running injury types and risk factors

Figure 1 shows the distribution of each RRI between male and female runners. Frequency of each RRI was compared between injured male and female runners using chi-square test. Men reported more AT than women (77.8% vs 22.2%, $X^2(1, N=432)=5.58, p=0.018$) and more PT than women (80% vs 20%, $X^2(1, N=432)=4.73, p=0.040$); women reported more ankle sprains than men (60% vs 40%, $X^2(1, N=432)=5.85, p=0.016$). No significant differences were found for frequencies of other RRI types between injured male and female runners ($p>0.05$).

All factors were entered separately into a univariate logistic regression with each injury type as dependent variable (additional file, Table S4-S7). The results of multivariate logistic regression are described for PFPS, MTSS, ITBS, and AT. The variables associated with PFPS were (Table 4): **running over 20 km/week** (OR 2.34, 95%CI 1.19-4.61), **over 3 sessions/week** (OR 0.33, 95%CI 0.17-0.63), **running company** (OR 2.31, 95%CI 1.36-3.93), **hard surface** (OR 1.40, 95%CI 1.10-1.78), **pes planus** (OR 1.98, 95%CI 1.02-3.85), **pes cavus** (OR 4.87, 95%CI 1.83-12.0), **obsessive passion** (OR 1.07, 95%CI 1.04-1.11), and **RAND 36-items** (OR 0.96, 95%CI 0.94-0.98).

The final step of backward stepwise method of multivariable logistic regression for variables associated with MTSS includes (Table 4): **over 3 sessions/week** (OR 0.43, 95%CI 0.22-0.83), **running company** (OR 2.05, 95%CI 1.18-3.58), **training program** (OR 1.95, 95%CI 1.11-3.41), **pes cavus** (OR 3.78, 95%CI 1.08-13.4), **hard surface** (OR 1.72, 95%CI 1.36-2.19), **treadmill surface** (OR 0.71, 95%CI 0.54-0.94), **sleep quality** (OR 1.51, 95%CI 1.11-2.05), **obsessive passion** (OR 1.05, 95%CI 1.01-1.09), and **RAND 36-items** (OR 0.95, 95%CI 0.93-0.98).

The final step of backward stepwise method of multivariable logistic regression for variables associated with ITBS includes (Table 4): **running over 20 km/week** (OR 4.16, 95%CI 1.59-10.9), **sleep quality** (OR 1.58, 95%CI 1.04-2.41), **obsessive passion** (OR 1.05, 95%CI 1.01-1.10), and **RAND 36-items** (OR 0.96, 95%CI 0.93-1.00).

The final step of backward stepwise method of multivariable logistic regression for variables associated with AT includes (Table 4): **overweight** (OR 5.70, 95%CI 2.08-15.6), **pes planus** (OR 4.65, 95%CI 1.69-12.8), **sleep quality** (OR 3.78, 95%CI 2.06-6.94), **obsessive passion** (OR 1.17, 95%CI 1.10-1.24), and **RAND 36-items** (OR 0.95, 95%CI 0.92-0.99).

Table 4: Results of multivariate logistic regression analysis* for each specific injury type

Injury Variables	Injured runners	PFPS	MTSS	Thigh strain	Meniscus injuries	ITBS	AT	Ankle sprain	PF	PT
Overweight	1.89 (1.24-2.88), p=0.003						5.70 (2.08-15.6), p=0.001		8.66 (2.49-30.28), p=0.001	6.65 (2.47-17.9), p<0.001
Over 20 km/week	1.52 (1.01-2.29), p=0.049	2.34 (1.19-4.61), p=0.014				4.16 (1.59-10.9), p=0.004		2.96 (1.09-8.06), p=0.033	8.91 (2.20-36.10),p=0.002	
2-5 years' experience									4.81 (1.17-19.77),p=0.030	
Over 5 years' experience									5.65 (1.43-22.39),p=0.014	
Over 3 sessions/week		0.33 (0.17-0.63), p=0.001	0.43 (0.22-0.83), p=0.012							
Warm-up								0.20 (0.07-0.61), p=0.004		
Running company	1.68 (1.19-2.38), p=0.003	2.31 (1.36-3.93), p=0.002	2.05 (1.18-3.58), p=0.011							
Training program	1.50 (1.08-2.07), p=0.015		1.95 (1.11-3.41), p=0.020		2.67 (1.20-5.90), p=0.016			0.16 (0.04-0.60), p=0.006		
Other sports					3.46 (1.16-10.3), p=0.026					
Hard surface	1.37 (1.18-1.59), p<0.001	1.40 (1.10-1.78), p=0.006	1.72 (1.36-2.19), p<0.001	1.35 (1.02-1.78), p=0.034	1.48 (1.10-2.01), p=0.011					
Treadmill surface			0.71 (0.54-0.94), p=0.015							
Pes planus	1.85 (1.17-2.94), p=0.009	1.98 (0.91-3.85), p=0.045			3.22 (1.35-7.65), p=0.008		4.65 (1.69-12.8), p=0.003	4.99 (1.95-12.8), p=0.001	43.0 (12.57-147.1),p<0.001	
Pes cavus		4.87 (1.83-12.0), p=0.002	3.78 (1.08-13.4), p=0.038					4.63 (1.26-17.1), p=0.021		

Special insole				4.02 (1.60-10.1), p=0.003						4.52 (1.47-13.9), p=0.008
Sleep quality	1.48 (1.22-1.80), p<0.001		1.51 (1.11-2.05), p=0.008			1.58 (1.04-2.41), p=0.031	3.78 (2.06-6.94), p<0.001			2.04 (1.10-2.79), p=0.024
Obsessive passion	1.05 (1.03-1.07), p<0.001	1.07 (1.04-1.11), p<0.001	1.05 (1.01-1.09), P=0.006			1.05 (1.01-1.10), P=0.016	1.17 (1.10-1.24), p<0.001	1.05 (1.04-1.11), p=0.033	1.11 (1.05-1.18), p=0.001	1.10 (1.03-1.16), p=0.003
RAND-36	0.96 (0.95-0.98), p<0.001	0.96 (0.94-0.98), p<0.001	0.95 (0.93-0.98), p<0.001	0.95 (0.93-0.98), p=0.001	0.92 (0.89-0.95), p<0.001	0.96 (0.93-1.00), p=0.023	0.95 (0.92-0.99), p=0.013	0.95 (0.92-0.99), p=0.008	0.87 (0.80-0.94), p<0.001	

* Odds ratio (95% CI) for categorical variables compared to the references specified in Table 3.

PFPS patellofemoral pain syndrome, MTSS medial tibial stress syndrome, ITBS iliotibial band syndrome, AT Achilles tendon injuries, PF plantar fasciitis, PT patellar tendinopathy.

4. Discussion

This study aimed to describe the epidemiology and etiology of RRIs specifically in Iranian recreational runners. We analyzed 804 questionnaires, 432 (54%) reporting at least one RRIs. Male-to-female proportion was 57-43%. Most-reported injury was PFPS (19.8%), followed by MTSS (16.9%). Most-affected injury location was the knee (44.6%), followed by the lower leg (19.2%). Of all variables analyzed together in multivariate logistic regression, overweight, running over 20 km/w, participating in other sports, having pes planus and/or cavus, poor sleep quality, greater obsessive passion, and lower RAND-36 score were associated with RRIs. Our study highlights the potential role of sleep quality, psychological factors, and the effects of abnormal foot arch in RRIs. Our findings will help researchers, trainers, clinicians, and policymakers develop preventive strategies and programs, eventually helping runners remain healthy and injury-free.

The prevalence of RRIs over the previous six months was 54%, fitting with previous studies on RRIs in recreational runners reporting a 36.5%-79.3% prevalence [5, 15, 24, 25]. The period over which injuries are reported and injury definition may affect injury incidence. Most-reported injury was PFPS, in line with previous studies [2, 26, 27]. MTSS was the second-most commonly reported RRI. Prevalence of PFPS (19.8) and MTSS (16.9) exceed other RRIs (<8.7). Men reported more AT and PT than women; women reported more ankle sprains than men. We found only one study that classified RRIs by gender, reporting more AT in men than women [28]. Knee was the most-affected injury site, with 47% of injuries attributed to a higher proportion of PFPS, fitting with previous studies identifying the knee as the most-common injured location in runners [2, 24, 26, 29]. The high knee injury rate may be attributed to the greater accumulated impact forces imposed on it when running.

Running over 20 km/w (OR 1.62-8.91) was associated with RRIs, which implies that runners may reduce their weekly running distance to a lower level of 20 km/w to prevent RRI. However, it seems that a safe running

distance may vary between populations and is related to other training factors. Contradictory results have been reported so far on running distance. A systematic review investigating RRI types did not reach agreement on the most appropriate and safe running distance [30].

Running on hard surfaces had between 1.35 and 1.72 higher odds of RRI types. Two studies highlighted hard-surface running as a risk for RRI types [27, 31]. By contrast, a prospective study reported that hard surface is not associated with RRI types in recreational runners [15]. Our results showed that hard-surface running was one of the contributing factors for the four most common RRI types. These results may account for hard-surface running causing greater musculoskeletal stress to the lower limbs than any other surface [32]. About 82% of participants reported at least one session/week running on asphalt and/or cement, surfaces that are most easily accessible. Results showed that treadmill running seems to result in less MTSS (OR 0.71), maybe because it reduces the total stress on lower leg musculoskeletal system compared to hard surfaces. Sub-group analyses indicated that female runners reported more treadmill sessions per week than men. About 62% of women reported at least one treadmill session/week, compared to 35% of men. Iranian female recreational runners usually prefer indoor running due to religious beliefs or hijab rules, making treadmills the best accessible indoor running option. Treadmill running was not a significant factor for other RRI types.

Besides physical demands, mental aspects also play an important role in sports performance such as running. These psychological factors affect both injury incidence [33] and injury rehabilitation [34]. Psychological factors influence training variables such as the training loads that a runner can tolerate before incurring an injury [35]. Our results showed that runners reporting a history of injury had more obsessive passion for running than those without such history. More importantly, obsessive passion or BERQ-2 (high correlation with obsessive passion in our study) was one of the factors associated with most RRI types. The effect of obsessive passion gained significance when an analysis of our participants revealed that runners reporting multiple injuries scored significantly higher obsessive passion than those with one injury. In fact, obsessive passion drives runners to keep on running while injured. This can lead to multiple and chronic injuries. Our results are in line with a previous study showing that long-distance runners with more obsessive passion were more prone to injury [36]. Because of their obsessive passion for running these runners do not sufficiently weigh the situation and circumstances leading to running excesses, thereby predisposing themselves to RRI types.

Injuries might have an impact on general well-being [37]. We also found an association between perceived health and RRI types. Runners with a history of injury reported lower RAND 36-item scores than those without any such history. A reduced RAND-36 score was shown for all types of RRI types (except for PT). Our analysis showed that injured female runners reported significantly lower perceived health than injured male runners. Injuries are speculated to have more health effects in women than men, or women with lower perceived health are more prone to injury than men. Due to our study design, it remains unclear whether the lower perceived health is cause or consequence of the RRI.

Our results also showed that poor sleep quality is associated with increasing RRI types odds by 3.78. Previous studies highlighted lack of sleep as a risk factor for sports injuries [38–41] while considering quantification of sleep. It seems that exploring sleep quality, as measured in our study, can be more relevant to studying sports injuries than exploring sleep quantity. Good sleep quality is necessary for skeletal musculature to adapt, repair,

and increase [38] concentration to better perform a sports activity like running, while poor sleep quality can reduce these factors and leads to injuries [39].

Pes planus and cavus are significantly associated with most of the RRIs. Runners with pes planus compared to those with normal feet had an odds ratio of 1.7 for MTSS to 4.3 for PF; those with pes cavus compared to normal feet had an odds ratio of 4.63 for ankle sprain to 4.87 for PFPS. A subgroup analysis revealed that about 50% of runners reporting multiple injuries had either pes planus or pes cavus. Previous studies also highlighted the importance of foot arch for RRIs [42–44]. A recent study showed that pes planus and cavus are associated with 20 to 77 times higher odds of RRIs than normal feet, respectively [43]. A systematic review reported that pes planus and cavus are associated with lower-limb injuries [45]. Another systematic review reported strong and limited evidence that pes planus is a risk factor for MTSS and PFPS, respectively [46].

Running in a group was associated by 2.3 times higher odds of reporting injuries. Nevertheless, it is difficult to conclude the causative effect of the association between running in a group or alone and RRIs. Our results showed that about 61% of runners who ran in a group followed a training program. Also, those following a training program showed higher odds of RRIs and MTSS. Group runners most likely follow the same training program. It could therefore be concluded that following the same group running program may increase the odds of RRIs. This indeed underlines the individuality principle in sports training. We therefore recommend individualization of training programs for runners.

4.1 Limitations and recommendations for future studies

Our survey results should be interpreted with caution. This is a retrospective study, so it is difficult to determine the causative association between risk factors and RRIs. Recall bias could also be a limitation of our study because all data were collected using a self-reported questionnaire. Although 89% of injuries and 60% of foot types were diagnosed by a physician or physiotherapist, which we believe increases the accuracy of data, injuries and foot type were self-reported. We also provided runners with a clear definition for each RRI to minimize this bias. Future prospective studies are warranted among Iranian recreational runners to substantiate RRI risk factors obtained from our study.

4.2 Practical implications

Our study describes potential risk factors for RRIs in Iranian recreational runners, which may be useful toward preventing and managing RRIs. Our findings are also important for runners who want to be aware of factors predisposing them to developing an RRI. These factors may be considered when preventing and/or managing RRIs: 1) correcting pes planus and cavus, 2) avoiding or reducing running on hard surfaces, 3) counseling for obsessive passion for running to avoid overdoing it, 4) controlling running distance, 5) personalizing the training program, 6) improving overall physical and mental health, and 7) enhancing sleep quality.

5. Conclusion

In Iranian runners too, the prevalence of RRIs is high. PFPS (19.8%) and MTSS (16.9%) were the most-reported injuries. Having pes planus or cavus, being overweight, running over 20 km/week, greater obsessive passion for

running, hard-surface running, lower perceived health, and poor sleep quality were the most important factors associated with RRI. Our results highlight the complex and multifactorial nature of RRI. Personalizing preventive and educational programs are important toward reducing the number of RRI.

List Of Abbreviations

*RRI*s running-related injuries, *OR* odds ratio, *CI* confidence interval, *PFPS* patellofemoral pain syndrome, *MTSS* medial tibial stress syndrome, *ITBS* iliotibial band syndrome, *AT* Achilles tendon injuries, *PF* plantar fasciitis, *PT* patellar tendinopathy.

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Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Tehran university institutional review board (IR.SSRI. 1398.154). Consent to participate was given before completing the questionnaire.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SHM participated in the study design, making the questionnaire, recruitment, data collection, analysis and interpretation of the data, drafting, and final preparation of the manuscript. JZ and JH participated in the study design, making the questionnaire, analysis and interpretation of the data, drafting, and final revising of the manuscript. RR and HM participated in the study design, making the questionnaire, recruitment, data collection, drafting, and final revising of the manuscript. BA participated in the study design, analysis and interpretation of the data, drafting, and final preparation of the manuscript. All authors have read and approved the final manuscript.

Tables

Table 1: Participants’ characteristics

Variable	Total participants (n=804)	Participants with injury history (n=432)	Participants without injury history (n=372)	P-value
Sex (male/female)				0.27
Female, n (%)	342 (42.5)	176 (40.7)	166 (44.6)	
Male, n (%)	462 (57.5)	256 (59.3)	206 (55.4)	
Total, n (%)	804	432 (54)	372 (46)	
Age (years)	27 (11)	27 (12)	27 (12)	0.48
BMI (kg/m²)	23 (3.6)	23 (3.9)	23 (3.4)	0.8
Normal, n (%)	644 (80.1)	336 (77.8)	308 (82.8)	0.087
Overweight, n (%)	150 (18.7)	92 (21.3)	58 (15.6)	
Obese, n (%)	10 (1.2)	4 (0.9)	6 (1.6)	
Running experience (years)	2 (4)	2 (4)	2 (3.2)	0.49
Up to 2, n (%)	452 (56.2)	244 (56.5)	208 (55.9)	0.109
Between 2 & 5, n (%)	198 (24.6)	96 (22.2)	102 (27.4)	
Over 5, n (%)	154 (19.2)	92 (21.3)	62 (16.7)	
Running distance (km/week)	15 (15)	15 (20)	15 (10)	0.04
Up to 10, n (%)	298 (37.1)	148 (34.3)	150 (40.3)	0.002
Between 10 & 20, n (%)	266 (33.1)	132 (30.6)	134 (36.0)	
Over 20, n (%)	240 (29.9)	152 (35.)	88 (23.7)	
Running sessions (No/week)	3 (2)	3 (2)	3 (2)	0.146
Up to 3, n (%)	558 (69.4)	304 (70.4)	254 (68.3)	0.52
Over 3, n (%)	246 (30.6)	128 (29.6)	118 (31.7)	
Running duration (min/session)	45 (30)	45 (30)	40 (30)	<0.001
Up to 60, n (%)	476 (59.2)	235 (54.4)	241 (64.8)	0.003
Over 60, n (%)	358(40.8)	197 (45.6)	131 (35.2)	
Running surface #				
Hard	1 (1)	2 (1)	1 (1)	<0.001
Soft	0 (0)	0 (0)	0 (0)	0.92
Treadmill	0 (1)	0 (1)	0 (0)	0.10
Others	0 (0)	0 (0)	0 (0)	0.43
Other sports				
Yes, n (%)	642 (79.9)	358 (82.9)	284 (76.3)	0.021
No, n (%)	162 (20.1)	74 (17.1)	88 (23.7)	
Warm-up				
Yes, n (%)	740 (92)	392 (90.7)	348 (93.5)	0.143
No, n (%)	64 (8)	40 (9.3)	24 (6.5)	
Cool-down				
Yes, n (%)	672 (83.6)	362 (83.8)	310 (83.3)	0.86
No, n (%)	132 (16.4)	70 (16.2)	62 (16.7)	
Foot type	62 (7.7%) reported "do not know"			
Normal, n (%)	564 (70.1)	282 (65.3)	282 (75.8)	<0.001
Pes planus, n (%)	131 (16.3)	89 (20.6)	42 (11.3)	
Pes cavus, n (%)	47 (5.8)	35 (8.1)	12 (3.2)	
Special shoes				
No, n (%)	248 (30.8)	124 (33.3)	124 (28.7)	0.21
Yes, n (%)	556 (69.2)	248 (66.7)	308 (71.3)	

Special insole				
No, n (%)	687 (85.4)	359 (83.1)	328 (88.2)	0.042
Yes, n (%)	117 (14.6)	73 (16.9)	44 (11.8)	
Running company				
Group, n (%)	252 (31.3)	146 (33.8)	106 (28.5)	0.11
Alone, n (%)	552 (68.7)	286 (66.2)	266 (71.5)	
Following a running program				
No, n (%)	424 (52.7)	213 (49.3)	211 (56.7)	0.036
Yes, n (%)	380 (47.3)	219 (50.7)	161 (43.3)	
Foot strike	32 (4%) reported "do not know"			
Rearfoot, n (%)	432 (53.7)	224 (51.9)	208 (55.9)	0.205
Midfoot, n (%)	192 (23.9)	116 (26.9)	76 (20.4)	
Forefoot, n (%)	148 (18.4)	76 (17.6)	72 (19.4)	
Sleep quality				
Very good	162 (20.1)	64 (14.8)	98 (26.3)	<0.001
Good	360 (44.8)	178 (41.2)	182 (48.9)	
Moderate	208 (25.9)	134 (31.0)	74 (19.9)	
Poor	64 (8.0)	48 (11.1)	16 (4.3)	
Very poor	10 (1.2)	8 (1.9)	2 (0.5)	
Obsessive passion	17 (11)	19 (13)	15.5 (10)	<0.001
RAND-36 questionnaire	80 (15.25)	78 (16.5)	82.13 (12)	<0.001
BERQ-2 questionnaire	11.4 (10)	11.4 (3.6)	11.4 (4.4)	0.594
SQUASH	4822.5(5370)	4770(4924)	4867.5 (6630)	0.751

Continuous data are expressed as medians and interquartile ranges (tested by the Mann-Whitney test). All categorical data are expressed by number of runners and percentages (using Chi-square test). Type of surface: hard (cement, asphalt), treadmill, soft (gravel, grass, off-road track), and other (synthetic, sand). Bold P-value shows the statistically significant difference between those with and without injury history (P<0.05).

Table 3: Results of univariate logistic regression analysis, injury versus injury-free runners

Variable	OR (95% CI)	P
Sex (male ^R)	0.85 (0.65-1.13)	0.27
Age	1.0 (0.98-1.02)	0.97
BMI		
Normal ^R	Reference	
Overweight	1.45 (1.01-2.09)	0.043*
Obese	0.61 (0.17-2.19)	0.45
Running Experience (years)		
Up to 2 ^R	Reference	
Between 2 & 5	0.80 (0.57-1.12)	0.20
Over 5	1.27 (0.87-1.83)	0.22
Running distance (km)		
Up to 10 ^R	Reference	
Between 10 & 20	1.0 (0.72-1.39)	0.99
Over 20	1.75 (1.24-2.48)	0.002*
Training sessions (No/pw)		
Up to 3 ^R	Reference	
Over 3	0.91 (0.67-1.22)	0.52
Running duration (min/session)		
Up to 60 ^R	Reference	
Over 60	1.54 (1.16-2.05)	0.003*
Other sports (No ^R)	1.50 (1.06-2.12)	0.022*
Training surface		
Hard	1.30 (1.14-1.48)	<0.001*
Soft	0.95 (0.78-1.15)	0.60
Treadmill	0.88 (0.75-1.02)	0.08*
Others	1.11 (0.90-1.41)	0.35
Warm-up (yes ^R)	1.48 (0.87-2.50)	0.15*
Cool-down (yes ^R)	0.97 (0.67-1.41)	0.86
Foot type		
Normal ^R	Reference	
Pes planus	2.12 (1.42-3.17)	<0.001*
Pes cavus	2.92 (1.48-5.74)	0.002*
Special shoes (yes ^R)	1.24 (0.92-1.68)	0.16*
Special insole (yes ^R)	1.32 (1.03-2.27)	0.11*
Running company (alone ^R)	1.28 (0.95-1.73)	0.11*
Running program (no ^R)	1.35 (1.02-1.78)	0.036*
Foot strike		
Rearfoot ^R	Reference	
Midfoot	1.22 (0.94-2.00)	0.088*
Forefoot	0.98 (0.68-1.42)	0.92
Poor sleep quality	1.68 (1.42-1.98)	<0.001*
Obsessive passion	1.04 (1.02-1.06)	<0.001*
RAND-36 questionnaire	0.97 (0.95-0.98)	<0.001*
BERQ-2 questionnaire	1.04 (0.99-1.08)	0.13*
SQUASH	1.00 (1.00-1.00)	0.43

^R reference values

* variables entered into multivariate logistic analysis for injured vs. non-injured runners.

Bold P-value shows the statistically significant association between the respective variable (independent variable) and injured vs. non-injured group (dependent variable) ($P < 0.05$).

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