Predictors of running-related injury among recreational runners: a prospective cohort study of the role of perfectionism, mental toughness and passion in running

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participants signed an informed consent form and all procedures were performed following the Declaration of Helsinki.

Summary statement for social media: Gain insights into preventing running-related injuries among recreational runners through our study, revealing significant impact of factors such as perfectionistic concerns, obsessive passion for running, and foot type, providing valuable knowledge for injury risk management strategies. #RunningInjuries #SportsPsychology #InjuryPrevention #RunnersHealth #PsychologicalFactors

Abstract

Background:

The health benefits associated with recreational running are challenged by the occurrence of running-related injuries (RRIs). Effective preventive measures require knowledge of sport injury etiology. Psychological factors such as perfectionism, mental toughness, and passion are believed to predispose to sports injury by influencing training behaviors, motivation to run, and suppression of feelings of fatigue and pain. Yet their association with RRIs are understudied.

Hypothesis:

Perfectionism, mental toughness, and passion predict an increased risk of RRIs in recreational runners.

Study Design:

Prospective cohort study

Level of Evidence:

Level 3.

Methods:

143 recreational runners (age 34.9 ± 13.9, 37% women) with a response rate of 76.5% answered an online questionnaire about their characteristics, running behaviors, and psychological variables (perfectionism, mental toughness, and running passion) as well as a sports injury survey. Then, as a primary outcome, RRIs were recorded biweekly for 6 months. The incidence of injuries was expressed as RRI/1000 hours of running. The association between predictive factors and RRIs was estimated using logistic regression.

Results:

The incidence of RRIs during follow-up was 5.16 per 1000 hours of running. The knee was the most often injured location (26.4%), followed by the foot (18.9%) and lower leg (13.2%). Higher obsessive passion for running (odds ratio (OR): 1.11; 95% confidence interval (CI):1.04-1.20) and perfectionistic concerns (OR: 1.22; CI:1.05-1.41) were associated with a greater risk of RRIs, as were previous injury (OR: 2.49; CI:1.10-5.70), weekly running distance (OR:1.10; CI: 1.03-1.16) and both supinated (OR:4.51; CI: 1.11-18.30) and pronated (OR:3.55; CI: 1.29-9.80) foot type. Following a running schedule (OR: 0.24; CI:0.09-0.66) was associated with a lower risk of RRIs.

Conclusion:

History of previous RRI, pronated and supinated foot type, weekly running distance, perfectionistic concerns, and obsessive passion increased RRI risk in recreational runners. Following a running schedule was a protective factor.

Clinical Relevance:

Multiple factors predict RRIs, including runners' psychological characteristics. These findings can inform the development of injury risk management strategies.

Keywords: athletic injury; etiology; overuse injury; risk factors; training program.

INTRODUCTION

Running as a physical activity is becoming increasingly popular among people,[35] evidenting from the increasing number of running events and the number of runners participating in them. The main reasons for taking part in running are its potential benefits to physical and/or mental health, weight loss, self-improvement, performance, and social interaction, among others.[14] Although running is associated with improved physical and mental health,[35] running-related injuries (RRIs) are frequent and should not be ignored.[48]

Reports indicate that the incidence and prevalence of RRIs are high.[8] For instance, the incidence of RRIs has been reported to range from 6.9 to 8.7 per 1000 hours of running in recreational runners.[48] RRIs are problematic not only for the injured, but also come at a high cost to society, due to clinical costs, absenteeism, and reduced productivity. In a 10-year follow-up study, RRIs were the most common reason for men and the third most common reason for women to stop running,[19] and RRIs have even been dubbed 'the main enemy of runners'.[17] Therefore, the prevention of RRIs should be considered a healthcare priority. Unfortunately, preventive interventions designed based on evidence-based risk factors have failed to decrease the total number of RRIs in recreational runners.[7] A reason for this could be the limited insight into the etiology of RRIs, so that preventive interventions are predominantly based on insights into the mechanisms leading to injury while ignoring relevant psychosocial determinants.

From a biomechanical model perspective, RRIs occur when repetitive loading applied to body tissues exceeds their maximum mechanical stress tolerance.[16] The non-training-related variables (e.g., biomechanical variables and anthropometric variables) themselves cannot cause injury;[25,27] runners do not suffer from RRIs just because they are overweight, older, or have a history of previous injuries,[27] but only when they practice running.[16] This means that running is not only necessary but indeed a sufficient cause for RRIs. Accordingly, causal frameworks have appeared recently that introduce training load as a central and necessary part of the causal path of RRIs.[1,30] In support, a previous study showed that training load is the key factor associated with 60% to 70% of RRIs.[16] Training variables that have been frequently reported as risk factors for RRIs include; running too far, running too fast, and rapid increase in weekly running distance or intensity.[16] It seems that these variables, in a broad sense, are related to motivation, suppression of

feelings of fatigue and pain, and exertion. Typically, highly motivated runners train harder and longer.[13] Although this may be desirable, in some cases this training behavior can become obsessive and excessive, eventually leading to RRIs. Additionally, RRIs normally take time to develop, and highly motivated runners may neglect early signs of injury development. Instead of reducing mileage, these runners may continue their running regimen that eventually leads to RRIs needing medical attention. Therefore, the design and success of preventive strategies do not only depend on modifying the training load, but also on recognizing and targeting the underlying disposition that can affect the training load, emphasizing the significance of understanding psychological factors to fully understand the possible causes of RRIs.

Among psychological factors influencing the training behaviors, motivation to run, suppression of feelings of fatigue and pain, perfectionism,[6,21,26] mental toughness,[2,3] and passion [4,28] are frequently mentioned. These psychological factors may influence training behaviors, to the extent that athletes show poor control over their training regimen and participate in excessive training, have a poor recovery, and/or rush to increase the training load, which may lead to RRIs.[15,49]

Perfectionism is characterized by striving to be flawless and setting very high standards for performance along with a tendency to over-critically evaluate one's behavior.[6] According to the two-factor model of perfectionism, perfectionism consists of two higher-order dimensions; perfectionistic strivings and perfectionistic concerns.[15] Previous retrospective studies show that there is a significant positive correlation between perfectionistic concerns and the number of injuries reported in the team and individual sports.[22,26] In another study, Lederbach and Campagno (2001) also showed that the level of perfectionism in injured dancers is higher than in uninjured dancers.[21] It should be noted that in this study, perfectionism was investigated as a one-dimensional personality trait.[21] Consequently, it is unclear which dimensions of perfectionism — perfectionistic strivings, perfectionistic concerns, or both — are responsible for this relationship. Although there is thus some evidence that perfectionism is related to an increased risk of sport injury, it is not clear whether these findings can be generalized to other sports populations (with different levels of training and competition stress) or not.

Mental toughness has also emerged as an important psychological trait in sports psychology in the last two decades.[11] Mental toughness is defined as a set of values, attitudes, behaviors, and

emotions that enable an athlete to persevere and overcome any obstacle, adversity, or pressure they experience that enables them to maintain their motivation and focus until reaching the goal.[12] Although mental toughness is generally considered a desirable trait, it is reasonable to ask: "Is it possible that a person is so mentally tough that it puts her or him at risk?" In line with this, it has been seen in a qualitative study that mentally tough athletes may not accept or understand medical advice about immediate care of their minor injury, thus exposing themselves to the risk of severe injury.[2] In line with this, rrugby players with higher mental toughness were more likely to engage in the activity while injured despite potential negative consequences.[24] It is also possible that mental toughness has a negative effect on adherence to rehabilitation resulting in a premature return to the activity which in turn increases the likelihood of re-injury.[3]

Passion is a strong inclination towards an activity that people like, find important, and invest time and energy on.[43] According to the Dualistic Model of Passion, there are two different types of passion based on how the passionate activity is internalized in the person's identity: Harmonious passion (HP) which is caused by the autonomous internalization of the activity in the person's identity, and obsessive passion (OP) which is caused by the controlled internalization of the activity in the person's identity.[42,45] It is suggested that those who show harmonious passion make a decision to participate in an activity or not based on their ability to harmoniously integrate it into other dimensions of life; in other words, they control the desire to participate in the activity. But those who show obsessive passion, experience an internal compulsion that is beyond the individual's self-control to participate in the activity, even when doing that activity clashes with other work, social or family responsibilities which cause considerable disruption to one's functioning.[4] Deroche, Stephan, Brewer, Le Scanff [4] reported that a history of injury, neuroticism, and obsessive passion are positive predictors of perceived susceptibility to sport injury in rugby players, while harmonious passion has an inverse relationship with susceptibility to sports injury. In addition, in a retrospective study, Mousavi, Hijmans, Minoonejad, Rajabi, Zwerver [28] showed that obsessive passion is related to RRIs. However, this was a self-report cross-sectional study that did not allow to establish causal links between variables and had the potential to be influenced by recall bias.

Identifying risk factors for RRIs can help design evidence-based injury prevention and risk reduction strategies. Although certain risk factors have been established, these data provide limited information for designing prevention strategies[7] and more research is needed in this field.

Therefore, the aim of this study was to identify demographic, running behavioral, and psychological risk factors related to RRIs using a multifactorial approach. Considering that there is some literature on the possible role of perfectionism, mental toughness, and passion in the occurrence of sports injuries, we hypothesized that these psychological factors increase the risk of RRIs in recreational runners.

METHODS

Study Design and Participants

This prospective cohort study examined the risk factors associated with RRIs among recreational runners. Baseline data consisting of psychological and behavioral measures as well demographic information were collected using an online/electronic questionnaire. Then, participants were monitored for 6 months, during which injuries and running information were recorded every two weeks. The study included 143 runners recruited through various channels, including flyers and posters in university clubs, running clubs and gyms, and online advertisements on pages of running groups (e.g., Telegram, WhatsApp, Instagram) in Sanandaj and Kermanshah cities of Iran from May 2021 to April 2022.

A recreational runner was defined as an individual aged between 18 and 65 who has regularly participated in recreational running for a minimum of 5 km per week at least 3 months prior to completing the questionnaire[28,48]. Participants were excluded from the study if they were currently injured or had sustained an injury within the three months prior to participation. Exclusion criteria also included current pregnancy, anterior cruciate ligament injury, joint reconstructive surgery or replacement, and unwillingness to record running data. This study received approval from the Ethics Committee of Shahrood University of Technology under the reference IR.SHAHROODUT.REC.1401.021. All participants signed an informed consent form, and all procedures were performed following the Declaration of Helsinki

Baseline measurements

Based on previous studies,[18,28] an online questionnaire was designed using Google Form. The electronic link of this online questionnaire was sent to the runners using communication tools

(WhatsApp, Telegram, Instagram, and Email). By clicking on this electronic link, the runners were directed to a page that encompassed 1) inclusion and exclusion criteria, 2) instructions for completing the questionnaires, and 3) a consent form. After agreeing to participate, the runners were directed to a website that contained the baseline survey. Open-ended questions were used to obtain characteristics data such as sex, age (year), height (cm) and weight (kg), which were used to calculate body mass index (BMI) (weight [kg]/height [m^2]). Runners were also asked about the type of foot arch. To help participants classify their foot arch, a graph of foot imprints with different arch heights was provided. These questions were followed by questions about the history of running injuries and the location of the injury. A specific question was included to confirm that runners were injury-free before starting this study. An RRI was defined as "*any musculoskeletal complaint that originated during running, regardless of the need for medical attention or any time loss from running activities*".[51] Finally, the participants completed three questionnaires regarding mental toughness, perfectionism and sports passion**.**

Mental toughness

Mental toughness was assessed using a 14-item Sports Mental Toughness Questionnaire (SMTQ) that is classified into three subscales: confidence (6 items), constancy (4 items), and control (4 items). Participants were asked to score each item (e.g., I interpret threats as positive opportunities) on a four-point Likert scale from 1 "not at all true" to 4 "very true". Total scores were calculated by summing the item scores for each subscale. Higher subscale scores indicate higher levels of each dimension and a higher composite score reflected higher global mental toughness. Good internal reliability was reported for confidence (α=0.80), constancy (α=0.74), and control (α=0.71) subscales.[36]

Perfectionism

Perfectionism was assessed using 8 items of Frost's multidimensional perfectionism scale that were classified into two four-item subscales: i) perfectionistic concerns and ii) perfectionistic strivings. Participants were asked to score each item (e.g., I have extremely high goals) on a five-point Likert scale from 1 "strongly disagree" to 5 "strongly agree". The total score was calculated by summing the scores of the items of each subscale, where higher subscale scores indicate more perfectionism tendencies in that dimension. Cronbach's α coefficient shows good internal consistency (α=0.73).[50]

Passion

Passion was assessed using a 12-item passion scale that was classified into two six-item subscales. Participants were asked to score each item (e.g., I interpret threats as positive opportunities) on a 7-point Likert scale from 1 "strongly disagree" to 7 "strongly agree". A total sum was calculated, and higher total and subscale scores indicate more perfectionistic tendencies. The total score was calculated by taking the average of the six item scores, which ranged from 1 to 7, where higher scores on each subscale indicated greater passion for activity in that specific dimension. Good internal reliability was reported for obsessive passion (α=0.88) and harmonious passion (α=0.78) subscales.[44]

Follow-up survey

After initial data collection to monitor any RRI and running profile, an online form was sent to runners through communication tools (WhatsApp, Telegram, Instagram, and Email). This online form was sent to the runners every two weeks for six months. It contained closed-ended questions regarding running profiles, such as running experience, distance, duration, frequency, surface, and shoes. Runners also had to report RRI (location, type, and severity of injury) if present. The severity of running injuries was graded according to the method defined by Taunton, Ryan, Clement, McKenzie, Lloyd-Smith, Zumbo [39], which categorizes injuries into four grades: Grade 1, where symptoms are experienced only after running; Grade 2, where symptoms are experienced during running but do not affect running distance or speed; Grade 3, where symptoms restrict running distance and speed; and Grade 4, where symptoms prevent running altogether. A reminder message was sent to the runners if they did not respond within three days. If runners had not completed the form within eight days after the initial message, they were then contacted by telephone to remind them to complete the form.

Statistical Analysis

Descriptive statistics were used to summarize the characteristics of the participants. Chi-square, Mann-Whitney, and Student's t-tests were used to compare differences between participants who developed RRI during the study and those who did not. The incidence of RRI was calculated as the number of new RRIs reported per 1000 hours of running exposure. The exposure to running

was calculated using the exposure time from the beginning of the study until the end of the follow-up (six months). A univariate logistic regression analysis was used to investigate a likely relationship between each independent variable and RRI as the dependent variable. Those variables that displayed a p-value < 0.20 were included in the multivariable logistic regression model with backward selection. To ensure that there is no multicollinearity among the independent variables, and to improve model fitting, the variance inflation factor (VIF) was assessed. The analysis revealed a maximum VIF value of 1.3, suggesting the absence of multicollinearity (as VIF > 3 indicates multicollinearity).[31] The odds ratio (OR) for each risk factor in the univariate and multivariate analyses were calculated, with 95% confidence intervals (CI). For categorical predictors, the odds ratio compares the odds of the event occurring for each category of the predictor in relation to the reference category. An odds ratio greater than 1 indicates higher odds for the event occurring in the desired category, while an odds ratio less than 1 suggests lower odds for the event occurring in the desired category compared to the reference category. When a predictor variable is continuous, the odds ratio represents the change in odds for a one-unit increase in the predictor variable. If the odds ratio is greater than 1, it indicates that the odds of the event occurring increases with each unit increase in the predictor variable. On the other hand, if the odds ratio is less than 1, it suggests a decrease in the odds of the event occurring with each unit increase in the predictor variable. All statistical analyses were performed using SPSS IBM version 26 with a significant level of 0.05.

RESULTS

Of the 187 runners who completed baseline questionnaires, 143 runners (female 37%, and 63% male) replied biweekly to injury status throughout the six-month follow-up (76.5%) as presented in Table 1. Table 1 summarizes the comparison of characteristics, training behaviors, and psychological attributes between runners who experienced RRI and those who did not. In our study, male runners constituted 63% of the total participants. In comparison to runners who remained injury-free, a higher percentage of those who sustained injuries had a prior history of RRIs (55% vs. 34.5%; $p < 0.05$), used special foot orthoses (37.5% vs. 16.5%; $p < 0.05$), and exhibited pronated (30% vs. 13%) and supinated feet (9.5% vs. 6.5%). Additionally, runners who developed RRIs covered longer weekly running distances ($p < 0.05$). Furthermore, individuals who

sustained injuries displayed significantly higher levels of obsessive passion for running, perfectionism concerns, and mental toughness ($p < 0.05$).

[**Table 1**]

During a six-month period, 53 out of 143 recreational runners (37%) experienced a total of 62 RRIs, averaging 0.43 injuries per runner. Among the injured runners, 79.3% (44/53) had one RRI, while 20.7% (11/53) suffered from multiple injuries. The incidence of RRIs during this time frame equated to 5.16 RRIs per 1000 hours of running exposure. Approximately 79.1% of self-reported injuries among runners were diagnosed by medical professionals like orthopedic specialists, sports medicines, physicians, or physiotherapists. The most frequently reported injury was patellofemoral pain syndrome (11.3%), followed by medial tibial stress syndrome (11.3%), and plantar fasciitis (9.7%) as per Table 2A. In terms of injury locations, the knee was the most commonly affected (25.8%), followed by the foot (22.6%) and lower leg (20.9%) (Table 2B). Regarding severity, most injuries were categorized as grade 1 (symptoms observed only after running; n=21) and grade 2 (symptoms observed during running but didn't affect running distance or speed; n=19). A total of 12.9% (n=8) of injuries were classified as grade 3, and only 8.1% (n=5) of injuries were severe enough to prevent running (grade 4) (Table 2C).

[**Table 2**]

Table 3 shows the results of univariate logistic regression analysis for runners' characteristics. Our study results indicate that history of previous RRI and pronated foot type are univariately associated with RRIs ($p < 0.05$).

[**Table 3**]

Table 4 shows the results of univariate logistic regression analysis for variables related to the training behavior of runners. Among variables related to the training behavior assessed at baseline, having a longer weekly running distance and using a foot insole were univariately associated with RRIs ($p < 0.05$). Running experience, running frequency, running duration, running surfaces, following a running schedule, running monitoring, participation in other sports, using running shoes, and warm-up and cool-down were not significant predictor variables of RRIs.

[**Table 4**]

Table 5 shows the results of univariate logistic regression analysis for psychological variables. The study reveals that higher levels of obsessive passion for running, perfectionistic concerns, and mental toughness are associated with increased odds of RRIs (all $p < 0.05$). However, perfectionistic strivings, harmonious passion and subcomponents of mental toughness such as confidence, stability and control were not significant risk factors of RRIs in recreational runners.

[**Table 5**]

Univariate analysis was performed on all variables and those that displayed a p-value < 0.20 were included in the multivariable logistic regression model with forward selection. Table 5 shows the variables included in the final regression model after the iterative process. The logistic regression model was statistically significant, $\chi^2(7) = 42.10$, $p < 0.001$. The model explained 34.8% (Nagelkerke R^2) of the variance in RRIs and correctly classified 76.2% of cases.

[**Table 6**]

DISCUSSION

The purpose of this prospective cohort study was to detect specific etiological factors associated with RRIs in recreational runners. The results showed that a history of previous RRI, pronated and supinated foot type, perfectionistic concerns and strivings, and obsessive passion are significant predictors for RRI in recreational runners.

Epidemiology

The incidence of RRI in this study was 5.16 RRI per 1000 hours of running exposure, which is consistent with previous studies on RRIs in recreational runners, reporting a 5.2-10 RRI per 1000 hours of running.[18,41,48] The injury definition and the period during which injuries are recorded may affect the incidence of injury.[48] In our study, runners self-reported their training exposure in web-based running diaries. This approach may lead to training hours or distance being estimated

wrongly, because of recall bias and time spent self-reporting. The location of observed injuries were also similar to previous studies, which have shown that the knee and foot are the most commonly affected anatomical regions.[18,41]

Runners' characteristics and training behaviors

The results of the present study show that a history of a previous injury is associated with a 2.91 times higher risk of RRI in recreational runners. The strength of the association found in our study is comparable to that reported by Junior, Costa, Lopes [18], who found an injury odds ratio of 2.2 (1.22 to 4.01) in recreational runners with a running previous injury. The "new" injury can be an exacerbation of a previous injury that has not fully recovered. In addition, injured runners may adopt a different biomechanical pattern to protect the injured anatomical region and this can expose them to new injuries.

The study's findings suggest that individuals with pronated feet have a 3.27 times higher risk of developing RRIs compared to those with normal feet, slightly higher than the 1.4-3.2 times higher risk reported by Mousavi, Hijmans, Minoonejad, Rajabi, Zwerver [28]. Although some systematic reviews reported a smaller risk increase,[29,40,46] overall it appears that foot pronation increases the risk of RRIs. The results regarding supinated feet revealed a conflicting perspective, as the analysis of foot type as a separate variable through univariate analysis did not demonstrate a significant correlation between a supinated foot and RRIs. But when the type of foot was analyzed by multivariate analysis along with other variables, the supinated foot compared to normal foot shows an OR of 6.19, almost twice as much as pronated foot. These paradoxical findings can likely be attributed to a confounding variable or variables that were considered in the multivariate logistic regression but not in the univariate analysis, emphasizing the importance of examining foot type in conjunction with other variables to assess the risk of RRIs. A prior study[33] aligns with the present research, indicating that both highly supinated and supinated foot types carry significantly higher injury odds, with odds ratios of 76.8 and 4.23, respectively, and highly pronated and pronated foot types also exhibit increased odds of injury, with odds ratios of 4.8 and 20. However, it's important to exercise caution when interpreting these results due to the low count of individuals with the supinated foot type relative to those with normal and pronated foot types.

We found that longer distance running was also associated with higher odds of RRIs, which could indicate that recreational runners should reduce their weekly running distance to a lower level to

prevent RRIs. However, Fredette, Roy, Perreault, Dupuis, Napier, Esculier [9] in a systematic review based on 36 studies (33 prospective, 3 RCTs) already outlined the conflicting level of evidence linking training parameters and RRIs. These conflicting results may be due to the lack of consistent definitions of injury, runner profiles, follow-up periods and reporting guidelines in the field of RRIs. Moreover, the relationship between training parameters and RRIs is certainly more complex than just training parameters *per se*.[10] Whatever other factors are important, the observation that longer running distance was associated with an increased risk of RRIs corresponds with the hypothesis that RRIs are due to an excess of repetitive loading on body tissues compared to their capacity to support it[16]. Excessive loading is, however, athlete-specific and depends on various factors including physical maturity, lifestyle, degree of recovery, and training load[9].

Psychological variables

Our study results show that a higher obsessive passion for running was associated with a higher risk of RRIs in recreational runners. For each unit increase in the score of the obsessive passion subscale, the risk of RRIs increases by 91% for recreational runners. In line with the results of the present research Mousavi, Hijmans, Minoonejad, Rajabi, Zwerver [28] among recreational runners and Stephan, Deroche, Brewer, Caudroit, Le Scanff [38] among competitive runners reported that obsessive passion is positively related to RRI and perceived susceptibility to sports injuries, respectively. Both studies were retrospective and did not report a cause-and-effect relationship. In addition, participants of Stephan, Deroche, Brewer, Caudroit, Le Scanff [38] study were competitive runners and RRIs were not measured directly, but perceived susceptibility to sports injuries was measured. Obsessive passion appears to be associated with deficits in self-regulatory processes[37] that likely causes runners to directly or indirectly tax their bodies beyond their limits. In line with this Paradis, Cooke, Martin, Hall [32] showed that obsessive passion is indeed related to unhealthy exercise behavior and exercise dependence, which is itself related to lower levels of self-control and maladaptive emotion regulation. This issue can explain the harmful nature of obsessive passion because it can prevent the adequate use of adaptive coping strategies and lead to an increased risk of sports injuries. For example, obsessive passion is considered a defensive, ego-invested, and avoidance-oriented approach to coping strategies,[47] which is likely to prevent adequate responses to the situation where training pressure exceeds the athlete's training capacity. However, contrary to this explanation, Stenseng, Rise, Kraft [37] showed that obsessive passion is related to under-regulation instead of overregulation in athletes. To reconcile these paradoxical

observations, our second proposition is that obsessive passion for running is negatively associated with the use of running-related coping strategies, such as utilizing running-related resources and engaging in running-related recovery, which thereby increase the risk of RRIs.

Our study also showed that perfectionistic concerns are associated with an increased risk of RRIs. For each unit increase in the score of the perfectionistic concerns subscale, the risk of RRIs increased by 22% for recreational runners. Consistent with the results of our study, Madigan, Stoeber, Forsdyke, Dayson, Passfield [22] on 80 junior athletes from team and individual sports showed that the risk of injury was increased by over 2 times for each 1 SD increase in perfectionistic concerns. A possible explanation for the relationship between perfectionistic concerns and RRIs comes from the perfectionism-training distress relationship.[23] Previous research has shown that perfectionistic concerns are associated with exercise dependence and can predict increases in training distress over time.[23] As such, perfectionistic athletes in the current study may have overtrained, that is, trained harder and for longer than non-perfectionistic athletes, making them more susceptible to an increased risk of injury.

Strengths and Limitations

The study has several strengths that should be highlighted. Firstly, the prospective design allowed for the examination of the causes of RRIs. Additionally, the study experienced relatively low participant attrition, with over 76% of participants completing the questionnaires at follow-up. However, it is important to acknowledge limitations of the study that may influence the interpretation of the results. Firstly, not all predictors of RRIs were available in this cohort study. This may have limited the comprehensiveness of the findings. Secondly, both exposure time and injuries were self-reported, which could lead to potential overestimation of exposure time, underestimation of injury occurrence, and incorrect diagnosis. This introduces a degree of subjectivity and potential measurement error. Another limitation is that all predictor variables were measured at the beginning of the study, without considering changes between baseline and the time of injury. This could overlook valuable insights into how these variables may have evolved and influenced the occurrence of RRIs over time. In present study, recreational runners were purposively selected, not randomly chosen from the target population, and the survey was distributed through clubs, gyms, and online advertisements on specific running group pages in

Sanandaj and Kermanshah cities of Iran. This may lead to an overrepresentation of runners connected to these channels and an underrepresentation of those not involved, potentially introducing selection bias. In addition, the inclusion of foot arch type as a self-report variable in our study could potentially result in a misclassification of foot arch type. However, efforts were made to minimize bias by providing participants with a clear definition of foot arch type and visual aids illustrating foot imprints with different arch heights. Furthermore, the study did not consider whether recreational runners were training for a specific race. This raises the possibility that some participants may have trained intensively for a particular event, potentially influencing the observed correlation between weekly running distance and RRIs. Finally, this study had a relatively small sample size and a short follow-up period (6 months).

Practical implications

To prevent running-related injuries, personalized training programs should consider risk factors such as a history of previous injury, foot type, weekly running distance, perfectionism concerns, and obsessive passion. These programs should recommend measures such as following a running schedule, controlling weekly running distance, accounting for a runner's foot type (pes planus and cavus), and counseling to increase awareness of the potential risk of obsessive passion and perfectionistic concerns. By incorporating these measures, runners can effectively reduce their risk of developing running-related injuries.

While many runners aim for improvement and achievements, it is important to strike a balance and avoid losing oneself entirely in running, as it may have suboptimal health-related consequences, including increased risk of exercise addiction[20]. Instead, the focus should be on enhancing runners' ability to control their running-related efforts, which can be achieved by reducing obsessive passion through a reappraisal of the importance of running and its associated efforts[45]. Furthermore, setting achievable and realistic goals is important, as unrealistic expectations can lead to frustration and an unhealthy obsession with performance. Engaging in non-running activities can also help diversify interests and promote overall fitness.

Practitioners can address perfectionistic concerns in runners by using cognitive-behavioral interventions[5] and guided self-help[34], as these methods have shown promise in reducing perfectionistic concerns in clinical studies. However, more research is needed to determine the effectiveness of these interventions in athletes.

CONCLUSION

Our study results demonstrated that the incidence of RRI in recreational runners was 5.16 RRIs per 1000 hours of running and the knee was the most affected anatomical region. The relevant risk factors for RRI in recreational runners were identified in this study as a history of previous RRI, more weekly running distance, pronated and supinated foot type, perfectionistic concerns, and obsessive passion, while the protective factor identified was following a running schedule.

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589 Table 1. Comparison of characteristics, training behaviors, and psychological attributes between runners who
590 experienced running-related injury and those who did not.

Variable	Total (n = 143)	Injured (n = 53)	Uninjured (n = 90)	p-value
Sex n (%)				
Male	90 (63%)	28 (52.8)	62 (69%)	0.04
Female	53 (37%)	25 (47.2)	28 (31%)	
Age (years), mean (SD)	34.9 (13.9)	36.6 (13.2)	34.0 (14.3)	0.27
Height (cm), mean (SD)	174 (6.7)	174 (6.7)	175 (6.8)	0.66
Weight (kg), mean (SD)	70.4 (12.2)	70.9 (11.1)	70.2 (12.8)	0.71
BMI (kg/m^2), mean (SD)	23.2 (3.9)	23.5 (4.2)	23.0 (3.8)	0.42
History of previous RRI, n (%)				
Yes	60 (42%)	29 (55%)	31 (34.5%)	***0.01***
No	83 (58%)	24 (45%)	59 (65.5%)	
Foot type, n (%)				
Normal	103 (72%)	32 (60.5 %)	72 (80%)	
Pronated	28 (19.5%)	16 (30 %)	12 (13 %)	***0.03***
Supinated	12 (8.5%)	5 (9.5 %)	6 (6.5 %)	
Running experience, n (%)				
Up to 2 years	19 (43.5%)	15 (28 %)	19 (21%)	
2-5 years	47 (33%)	26 (49 %)	44 (49%)	0.56
5-10 years	24 (16.5%)	10 (19%)	19 (21%)	
Over 10 years	10 (7%)	2 (4 %)	8 (9%)	
Weekly running frequency (sessions/wk) median (IQR)	2 (1)	2 (1.5)	2 (1)	0.14
Running duration (min/session) median (IQR)	45 (20)	45 (17)	45 (22)	0.42
Weekly running distance (km/wk) median (IQR)	15 (10)	20 (10)	15 (10)	***0.01***
Running surface (times/wk) median (IQR)				
Hard (asphalt and cement)	1.0 (2.0)	2.0 (3.0)	1.0 (2.0)	0.11
Soft (running track and grass)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.23
Treadmill	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.76
Other (sand track and artificial surfaces)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.49
Following a running schedule, n (%)				
Yes	99 (69%)	32 (60.4%)	67 (74.4%)	
No	44 (31%)	21 (39.6%)	23 (25.6%)	0.06
Running monitoring, n (%)				
Nobody	89 (62%)	35 (66%)	54 (60%)	
Apps	*26 (18%)*	8 (15.0%)	18 (20.0%)	0.72
Coach	28 (20%)	10 (19%)	18 (20.0%)	
Other sport participation, n (%)				
Yes	78 (54.5%)	32 (60%)	46 (51%)	0.18
No	65 (45.5%)	21 (40%)	44 (49%)	
Running shoes, n (%)				
Yes	110 (77%)	41 (63.5%)	69 (77%)	0.55
No	33 (23%)	12 (36.5%)	21 (23%)	
Foot insole, n (%)				
Yes	35 (24.5%)	20 (37.5 %)	15 (16.5 %)	***0.005***
No	108 (75.5%)	33 (62 %)	75 (83%)	
Warm up, n (%)				
Never	7 (5%)	4 (7.5%)	3 (3.3%)	
Sometime	73 (51%)	26 (49%)	47 (52%)	0.53
Always	63 (44%)	23 (43.5%)	40 (44.5%)	
Cool down, n (%)				
Never	22 (15.5%)	9 (17 %)	13 (14.5%)	0.26
Sometime	71 (50%)	30 (56.5%)	41 (45.5%)	
Always	50 (35%)	14 (26.5%)	36 (40 %)	
Mental toughness, mean (SD)	42.5 (4.3)	43.0 (4.1)	41.4 (4.3)	***0.04***

Confidence	18.1 (3.1)	18.5 (2.8)	18.0 (3.3)	0.36
Stability	11.9 (2.3)	12.3 (2.4)	11.7 (2.2)	0.13
Control	12.0 (2.2)	12.2 (2.4)	11.8 (2.1)	0.24
Perfectionism, mean (SD)				
Perfectionism concerns	11.0 (2.8)	11.8 (2.8)	10.5 (2.7)	***0.01***
Perfectionism strivings	13.5 (3.2)	14.2 (3.0)	13.1 (3.3)	0.05
Running passion, mean (SD)				
*Obsessive passion**	3.2 (1.0)	3.4 (1.0)	3.0 (1.0)	***0.02***
Harmonious passion	5.9 (0.7)	5.9 (0.7)	5.9 (0.7)	0.65

Continuous data, like mean and standard deviation (SD), were analyzed using the independent t-test, while categorical data, represented by the number of runners and percentages, were analyzed using the Chi-square test. For variables like running surface types, weekly running frequency, running duration, and weekly running, the analysis was performed using the Mann-Whitney test, and the results are presented as median and interquartile range (IQR). The bold and italicized p-value indicates a statistically significant difference between runners with RRI and those without it.

Table 2. Running related injury by type and location

Type	n (%)	Location	n (%)	Severity	n (%)
Patellofemoral pain syndrome	7 (11.3)	Knee	16 (25.8)	Grade 1	21 (33.9)
Medial tibial stress syndrome	7 (11.3)	Foot	14 (22.6)	Grade 2	19 (30.6)
Plantar fasciitis	6 (9.7)	Lower leg	13 (20.9)	Grade 3	8 (12.9)
Ankle sprain	5 (8.1)	Ankle	7 (11.3)	Grade 4	5 (8.1)
Thigh strain	5 (8.1)	Thigh	4 (6.6)		
Calf strain	4 (6.6)	Hip/groin/buttock	3 (4.8)		
Lower back pain	4 (6.6)	Lower back	3 (4.8)		
Iliotibial band friction syndrome	4 (6.6)	Others	2 (3.2)		
Knee sprain	2 (3.2)				
Achilles tendinopathy	2 (3.2)				
Patellar tendinopathy	2 (3.2)				
Meniscus or cartilage injury	1 (1.6)				
Others	13 (20.9)				

Table 3. Univariate logistic regression analysis to predict running-related injury (RRI) by the runners' characteristics

Variable	**Odds ratio (95%CI)**	**p-value**
Sex (*Male*^{R})*	1.98 (0.98-3.98)	0.06
Age (years))	1.01 (0.99-1.04)	0.29
Height (cm)	0.99 (0.94-1.04)	0.68
Weight (kg)	1.01 (0.98-1.03)	0.70
BMI (Kg/m^2)	1.04 (0.95-1.13)	0.38
History of previous RRI *(No*^{R})*	2.32 (1.15-4.60)	***0.02***
Foot type (*Normal*^{R})*		
Pronated	3.12 (1.3-7.3)	***0.01***
Supinated	2.31 (0.7-7.7)	0.21

Abbreviations; CI = confidence interval, BMI = body mass index. R; reference category. *; variables entered into the multivariable logistic analysis. The bold and italicized p-values highlight the variables that significantly predict RRI.

607 Table 4. Univariate logistic regression analysis to predict RRI by the runners' training behaviors

Variable	Odds ratio (95%CI)	p-value
Running experience (*Up to 2 years*^{R})		
2-5 years	0.75 (0.33-1.71)	0.46
5-10 years	0.67 (0.24-1.85)	0.42
Over 10 years	0.32 (0.06-1.72)	0.18
Weekly running frequency (session/wk)*	1.22 (0.90-1.65)	0.19
Running duration (min/session)	1.01 (0.99-1.03)	0.62
Weekly running distance (km/wk)*	1.05 (1.01-1.09)	***0.03***
Running surface (times/wk)*		
Hard (asphalt and cement)	1.22 (0.96-154)	0.12
Soft (running track and grass)	0.81 (0.50-1.30)	0.42
Treadmill	0.99 (0.75-1.30)	0.87
Other (sand track and artificial surfaces)	083 (0.47-1.46)	0.54
Following a running schedule (*Yes*^{R})*	1.91 (0.93-3.95)	0.13
Running monitoring (*Nobody*^{R})		
Apps	0.69 (0.27-1.75)	0.38
Coach	0.86 (0.36-2.07)	0.66
Other sport participation (*No*^{R})	1.46 (0.73-2.90)	0.28
Running shoes (*Yes*^{R})	1.04 (0.46-2.33)	0.86
Foot insole (*No*^{R}) *	3.01 (1.4-6.6)	***0.01***
Warm up (*Never*^{R})		
Sometime	0.42 (0.09-2.0)	0.29
Always	0.43 (0.09-2.1)	0.27
Cool down (*Never*^{R})		
Sometime	1.06 (0.40-2.79)	0.89
Always	0.47 (0.20-1.61)	0.27

608 **Abbreviations**: CI = confidence interval, IQR = interquartile range. R; reference category. *; variables entered into
609 the multivariable logistic analysis. The bold and italicized p-values highlight the variables that significantly predict
610 RRI.
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613 Table 5. Univariate logistic regression analysis to predict RRI by the runners' psychological characteristics

Variable	Odds ratio (95%CI)	p-value
Mental toughness, mean (SD)*	1.12 (1.0-1.18)	***0.04***
Confidence	1.13 (0.94-1.18)	0.38
*Stability**	1.12(0.98-1.3)	0.12
*Control**	1.1 (0.94-1.29)	0.21
Perfectionism, mean (SD)		
*Perfectionism concerns**	1.20 (1.05-1.37)	***0.01***
*Perfectionism strivings**	1.12 (1.00-1.25)	0.05
Running passion, mean (SD)		
*Obsessive passion**	1.52 (1.02-2.15)	***0.02***
Harmonious passion	0.89 (0.56-1.43)	0.64

614 **Abbreviations**: CI = confidence interval. *; variables entered into the multivariable logistic analysis. The bold and
615 italicized p-values highlight the variables that significantly predict RRI.
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619 Table 6. Multivariate logistic analysis

Variables	B	S. E	Wald	Odds ratio (95%CI)	p-value
History of previous RRI (*No*^{R})	1.07	0.42	6.38	2.91 (1.27-6.64)	**0.01**
Foot type (*Normal*^{R})					
Pronated	1.18	0.53	5.11	3.27 (1.17-9.16)	**0.02**

Supinated	1.82	0.77	5.76	6.19 (1.41-27.27)	**0.02**
Weekly running distance	0.09	0.03	8.81	1.10 (1.03-1.16)	**0.003**
Following a running schedule (*Yes*^{R})	-1.42	0.51	7.65	0.24 (0.09-0.66)	**0.006**
Perfectionism concerns	0.20	0.08	6.68	1.22 (1.05-1.41)	**0.01**
Obsessive passion	0.65	0.22	8.58	1.91 (1.24-2.94)	**0.003**

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