

# LOWER EXTREMITY INJURIES IN NOVICE RUNNERS: INCIDENCE, TYPES, TIME PATTERNS, SOCIODEMOGRAPHIC AND MOTIVATIONAL RISK FACTORS IN A PROSPECTIVE COHORT STUDY

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**SUMMARY** – The aim was to determine types and incidence of running-related lower extremity injuries and identify sociodemographic and motivational risk factors in novice runners attending an eight-month running school. Between January 2011 and October 2014, 349 novice runners were included. Sociodemographic, anthropometric, and data on running motivation and self-perceived health and fitness were collected. Subjects were screened for lower extremity injuries at regular three-month intervals. The cohort mean age was 35.46±7.31 years, and 271 (79.5%) were female. There were 173 (49.9%) injuries recorded, less frequently among women (42.9% vs. 62.7%, p=0.016; OR 0.878, 95% CI 0.788-0.977). The mean body mass index was 23.89±3.88 kg/m<sup>2</sup> at baseline and 22.99±3.35 kg/m<sup>2</sup> post-school (p<0.001). Median self-perceived fitness level on a ten-point visual analog scale was 4 (interquartile range (IQR) 3-5) at baseline and 8 (IQR 7-8) post-school (p<0.001). Median self-perceived overall health was 6 (IQR 5-8) at baseline and 8 (IQR 7-9) post-school (p<0.001). The knee had a significantly higher rate of injuries compared to other anatomic regions (p<0.001). Subjects listed improvement of fitness as the most common motivation for entering the school (n=159; 45.7%). In conclusion, novice runners should include strengthening exercises for knee injury prevention into their training routine.

**Key words:** *Running – injuries; Knee injuries; Lower extremity – injuries; Risk factors; Surveys and questionnaires; Exercise; Motivation; Cohort studies*

## Introduction

Running is one of the simplest, most natural and accessible physical recreation activities for health maintenance and disease prevention. Millions of people worldwide engage in running as a daily recreational activity and take part in organized races, on novice, professional, and elite levels. Data from the United States of America show that in 2013 there were more than 50 million participants in organized running activities, and this number is believed to be an underesti-

mate, considering that a sizeable proportion of participations do not enter the statistics<sup>1</sup>. In Croatia, there is a lack of organized running for novices, as athletic clubs mostly recruit professionals or young athletes. Aimed at providing a wider-scale boot camp for novice runners, the 'school for runners' was introduced in 2011 in Zagreb, the country capital. During an eight-month period, novices with varying physical fitness levels were systematically prepared to complete a half marathon (21.2 km)<sup>2</sup>. Since 2011, more than thousand participants completed the school and later remained active runners at varying levels.

Although introductory fitness programs have numerous benefits and positive life changing effects, some participants experience medical issues, mostly

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musculoskeletal injuries. Painful joints, muscles and tendons are the usual complaints among the school participants. There are numerous factors associated with injuries in runners and subsequent pain and the inability to train or complete the course. In general, injuries in novice runners are caused by inappropriate running programs or insufficient conditioning of the musculoskeletal system prior to entering a course, even if the progression in training loads is slow. In more experienced runners, injuries are caused by overtraining and overuse during longer periods<sup>3-8</sup>. The pain is mostly in lower extremities and its origin is musculoskeletal system lesion<sup>9-12</sup>.

Musculoskeletal system related running injuries can be defined as discomfort or pain in any part of the system that is severe enough to cause running activity to be decreased or stopped for longer than seven days<sup>13</sup>. Most published studies on injuries in runners included experienced novices or elite runners<sup>11-24</sup>. Studies on novice runners are scarce, and most of them with a follow-up of no longer than several weeks<sup>25-28</sup>.

The aim of our research was to determine types and incidence of running related lower extremity injuries and to identify sociodemographic and motivational risk factors in novice runners attending an eight-month running school program. The results of our study would be used to create an injury prevention strategy and implement it into the course of the school for runners.

## Subjects and Methods

### *The school for runners*

The eight-month school for runners begins in March and lasts until the end of October, when the annual Zagreb Marathon is held. The majority of the school participants aim at completing the half-marathon event. During the first month of the school, the participants are divided into groups of 20 runners and each group is assigned a coach throughout the course. Three training sessions are held weekly, usually in the duration of 45 to 60 minutes. The session begins with a warm-up period, followed by specific strengthening exercises for runners. The remainder of the training session consists of walk-run intervals starting with one-minute walk one-minute run intervals. Towards the end of the session, the running intervals are pro-

gressively prolonged. The session ends with cool-down exercises. After one month, the majority of the participants can run uninterruptedly for at least a kilometer. Based on their one-kilometer results, they are re-allocated to groups of 20 runners. The next milestone is reached at three months of training when participants are given the option to participate in a designated 5-km race; at the race, they are paced by school trainers, according to their best times achieved. After the 5-km race, the training sessions are held four times weekly. The next milestone is reached after five to six months when participants are given the option to participate in a 10-km race. After the 10-km race, the training sessions are held five times weekly. After seven to eight months, the participants reach a level of fitness that enables them to finish a half-marathon, usually at the aforementioned annual Zagreb Marathon. The school is led and supervised by certified kinesiologists and kinesiology students who provide feedback to a medical doctor with regard to medical issues of the participants.

### *Subjects*

Participants having enrolled in the school for runners between 2011 and 2014 were included in the study. Lower age limit was set at 18 years and participants were screened for running contraindications by a medical doctor before the first session. A medical doctor was present at all training sessions and participants were encouraged to communicate their health concerns. All participants gave their consent to participate in the study.

### *Data collection*

Upon entry, sociodemographic (age and sex) and anthropometric (height and weight) data were collected on a predefined form. From the anthropometric data, the body mass index (BMI) was calculated using the formula: weight in kilograms divided by height in meters squared. BMI was re-calculated at the final session of the course. Apart from these data, a questionnaire was administered to the participants upon entry to assess for: (i) past injuries, (ii) past sports engagements, (iii) self-perceived overall health, (iv) level of fitness (on a 10-point scale), (v) motivation for enrollment in the school, and (vi) whether or not they were planning to complete a marathon. At the final session,

a questionnaire was administered to assess: (i) whether during the course an injury occurred (injury was defined as pain in lower extremities, originating from the musculoskeletal system), (ii) anatomic region of the injury, (iii) duration of the injury, (iv) whether the injury caused the participant to abandon the school, (v) which type of training session they found to be easiest/most difficult, (vi) 5-km and half-marathon time (if successfully completed), (vii) whether or not they used additional counseling from sources other than ones provided in the school, and (viii) regularity of session attendance. After collecting all questionnaires, data were copied into an Excel spreadsheet.

### Statistical analysis

Shapiro-Wilk test was used to test normality. Continuous variables were summarized as mean (standard deviation, SD), differences between two groups were assessed using *t*-test and differences among more than two groups using ANOVA. Ordinal variables were summarized as median (interquartile range, IQR), differences between two groups using Mann-Whitney *U*-test, and differences among more than two groups using Kruskal-Wallis test. Dichotomous variables were summarized as absolute (relative) frequency, and differences were assessed using  $\chi^2$ -test. All tests were two-sided and the level of significance was set at 0.05, with adjusted *p* values for multiple comparisons. The SPSS ver. 17.0 (Chicago, IL, USA) and Graphpad Prism ver. 6.0 (Graphpad Software, San Diego, CA, USA) were used on analyses.

## Results

In the observed period, 349 participants were enrolled. Their mean age was  $35.46 \pm 7.31$  years and 271 (79.50%) were women. Injuries were reported by 173 (49.90%) participants. The mean BMI was  $23.89 \pm 3.88$  kg/m<sup>2</sup> at baseline and  $22.99 \pm 3.35$  kg/m<sup>2</sup> after the school ( $p < 0.001$ ). The 5-km race was completed by 234 (67.10%) participants in the mean time of  $30.50 \pm 6.44$  min. The half-marathon (21.097 km) was completed by 214 (61.30%) participants in the mean time of  $129.96 \pm 30.85$  min. One hundred and ninety-eight (55.30%) participants were planning to complete a marathon (42.2 km). Median self-perceived level of fitness was 4.00 (3.00-5.00) at baseline and 8.00

(3.00-5.00) after the school ( $p < 0.001$ ). Median self-perceived overall health status was 6.00 (5.00-8.00) at baseline and 8.00 (7.00-9.00) after the school ( $p < 0.001$ ). The majority of participants (76.90%) had a history of sports activity engagement ( $p < 0.001$  for theoretical distribution). Also, the majority (82.60%) of participants did not use additional counseling from sources other than those provided in the school ( $p < 0.001$  for theoretical distribution). The knee was the anatomic region most frequently injured, significantly more often compared to other regions ( $p < 0.001$ ). The long slow distance was perceived as the easiest training session by 141 (40.40%) participants and fartlek as the most difficult one by 103 (29.50%) participants ( $p < 0.001$ ). As the main motivation for enrollment, the participants reported improvement of fitness ( $n = 159$ , 45.70%). Detailed subject characteristics are listed in Table 1.

When comparing injured and not injured participants, there were significant differences in: (i) median self-perceived overall health status before and after the school (8.00, IQR 7.00-9.00 *vs.* 8.00, IQR 7.00-9.00,  $p = 0.026$ ), (ii) proportion of women (74.30% injured *vs.* 84.50% not injured,  $p = 0.023$ ), and (iii) history of sports activity engagement (23.80% injured *vs.* 14.50% not injured,  $p = 0.048$ ) (Table 2).

With regard to sex, significant differences were recorded in baseline BMI (women  $23.20 \pm 3.32$  kg/m<sup>2</sup> *vs.* men  $26.80 \pm 4.81$  kg/m<sup>2</sup>,  $p = 0.007$ ) and BMI after the school (women  $22.30 \pm 2.64$  kg/m<sup>2</sup> *vs.* men  $25.69 \pm 4.35$  kg/m<sup>2</sup>,  $p = 0.002$ ). Also, there was a significant difference in the proportion of injured participants (women 46.70% *vs.* men 62.90%, relative risk 0.88, 95.00% CI 0.79-0.98), proportion of participants who planned to complete a marathon (women 52.40% *vs.* men 70.00%,  $p = 0.008$ ), and type of training session perceived to be most difficult ( $p = 0.042$ ).

## Discussion

In our study, 173 (49.90%) runners reported injuries. The incidence of injuries was substantially higher compared to previously published research with a shorter and comparable follow-up, and lower compared to research with a longer follow-up. In their meta-analysis on injuries in different populations of runners, Kluitenberg *et al.* report summary estimates of incidence of injuries among novice runners<sup>10</sup>. They

Table 1. Subject characteristics

Variable	N	Mean	SD	p value
Age (years)	349	35.46	7.31	
BMI at baseline (kg/m <sup>2</sup> )	348	23.89	3.88	<0.001*
BMI after school (kg/m <sup>2</sup> )	348	22.99	3.35	
BMI difference (kg/m <sup>2</sup> )	348	0.90	1.24	
Time at 5 km (min)	234	30.50	6.44	
Time at half-marathon (min)	214	129.96	30.85	
		Median	IQR	
Self-perceived overall fitness at baseline	348	4.00	3.00-5.00	<0.001†
Self-perceived overall fitness after school	346	8.00	7.00-8.00	
Self-perceived overall health at baseline	348	6.00	5.00-8.00	<0.001‡
Self-perceived overall health after school	346	8.00	7.00-9.00	
Regularity of session attendance	348	8.00	7.00-9.00	
		Frequency	%	
Sex (female)	349	271	79.50	
Injury (yes)	349	173	49.90	
Planned marathon (yes)	344	193	55.30	
<b>History of sports activity</b>	347			
No		80	23.10	<0.001§
Yes		66	19.00	
Periodically		201	57.90	

Variable	N	Mean	SD	p value
<b>Anatomic region of injury</b>	173			
Foot	30	8.60		
Ankle	30	8.60		
Lower leg	19	5.40		
Knee	76	21.80		
Upper leg	9	2.60		
Hip	9	2.60		
Lower back	9			
<b>Additional counseling</b>	344			
No	140	40.60		
Yes	60	17.40		
Periodically	145	42.00		
<b>Easiest session</b>	345			
Speed	14	4.00		
Intervals	123	35.20		
Long distance	141	40.40		
Tempo	34	9.70		
Fartlek	18	5.20		
Other	15	4.30		
<b>Most difficult session</b>	344			
Speed	61	17.50		
Intervals	30	8.60		
Long distance	93	26.60		
Tempo	49	14.00		
Fartlek	103	29.50		
Other	8	2.30		
<b>Motivation for enrollment</b>	348			
Fitness improvement	159	45.70		
Health improvement	43	12.40		
Stress reduction	72	20.70		
Competitive motivation	8	2.30		
Reducing weight	33	9.50		
Other	33	9.50		

SD = standard deviation; BMI = body mass index; IQR = interquartile range; \*t-test (baseline *vs.* post-school BMI); †Mann Whitney U-test (baseline *vs.* post-school perceived fitness); ‡Mann Whitney U-test (baseline *vs.* post-school perceived overall health); § $\chi^2$ -test

Table 2. Difference between injured and not injured runners

	Injury			Without injury			p value
	N	Mean	SD	N	Mean	SD	
Age (years)	173	35.77	8.15	174	35.16	6.42	0.432
BMI at baseline (kg/m <sup>2</sup> )	173	24.19	4.26	174	23.62	3.46	0.171
BMI after school (kg/m <sup>2</sup> )	173	23.21	3.75	174	22.80	2.89	0.262
BMI difference (kg/m <sup>2</sup> )	173	0.98	1.31	174	0.82	1.16	0.208
Time at 5 km (min)	123	30.33	5.99	110	30.65	6.96	0.706
Time at half-marathon (min)	117	130.32	26.82	96	129.33	35.38	0.816
		Median	IQR		Median	IQR	
Self-perceived overall fitness at baseline	173	4.00	3.00-5.00	174	4.00	2.00-5.50	0.285
Self-perceived overall fitness after school	173	8.00	7.00-8.00	174	8.00	7.00-9.00	0.406
Self-perceived overall health at baseline	173	6.00	5.00-8.00	174	7.00	5.00-8.00	0.158
Self-perceived overall health after school	173	8.00	7.00-9.00	174	8.00	7.00-9.00	0.026*
Regularity of session attendance	173	8.00	7.00-9.00	174	8.00	7.00-9.00	0.562
		Frequency	%		Frequency	%	
Sex (female)	171	127	74.30	168	142	84.50	0.023*
Planned marathon (yes)	171	100	58.50	172	92	53.50	0.352
<b>History of sports activity</b>	173			172			
No		38	21.90		42	24.40	
Yes		25	14.50		41	23.80	0.048*
Periodically		110	63.60		90	52.30	
<b>Additional counseling</b>	172			172			
No		61	35.50		79	46.00	
Yes		33	19.20		26	15.10	0.137
Periodically		78	45.30		67	38.90	
<b>Easiest session</b>	172			172			
Speed		10	5.80		4	2.30	
Intervals		53	30.80		70	40.70	
Long distance		74	43.00		66	38.40	0.276
Tempo		18	10.50		16	9.30	
Fartlek		8	4.70		10	5.80	
Other		9	5.20		6	3.50	
<b>Most difficult session</b>	172			171			
Speed		34	19.80		26	15.20	
Intervals		17	9.90		13	7.60	
Long distance		39	22.70		54	31.60	0.423
Tempo		23	13.40		26	15.20	
Fartlek		54	31.40		49	28.70	
Other		5	2.90		3	1.70	
<b>Motivation for enrollment</b>	173			174			
Fitness improvement		75	43.30		84	48.30	
Health improvement		19	11.00		23	13.20	
Stress reduction		36	20.80		36	20.70	0.678
Competitive motivation		5	2.90		3	1.70	
Reducing weight		18	10.40		15	8.60	
Other		20	11.60		13	7.50	

SD = standard deviation; BMI = body mass index; IQR = interquartile range; t-test was used for comparison of means, ordinal variables were compared using Mann Whitney U-test, and nominal variables using  $\chi^2$ -test; \*statistically significant

grouped the studies according to follow-up into three groups: (1) short follow-up (6-15 weeks); (2) one-year follow-up (11-13 months); and (3) follow-up longer than one year. Also, they grouped the studies according to injury definition into: (1) medical attention; (2) time-loss; and (3) pain related. They pooled the results of time-loss injuries during a short follow-up/recall period of four studies, and summary estimate was 26.40% (95.00% CI 14.20, 43.70). For a one-year period, they identified one study, with a proportion of injuries of 27.30% (95.00% CI 24.50, 30.30), and one study for a follow-up longer than one year, with a proportion of injuries of 84.90% (95.00% CI 74.60, 92.20). These results indicate that the incidence of injuries rises with the length of the study (differences between studies might also be attributable to different injury definitions and study populations). Nevertheless, the incidence of injuries in our study (49.90%) was significantly higher than in the study by Nilsen *et al.* (27.30%), which had a comparable follow-up. Their cohort had a lower proportion of women (49.70%)<sup>26</sup>. Since we found female sex to be associated with a lower incidence of injuries, this difference could be even bigger if the cohorts were comparable by sex. Age and BMI were similar to that in our study<sup>26</sup>. The difference that might explain the higher incidence of injuries in our cohort is the running schedule and the goal of the school, i.e. to prepare for a marathon. We believe that the higher incidence of injuries in our study might be attributable to the high mileage, high proportion of runners (55.30%) who entered the school as a preparation for a marathon, and high proportion of runners who completed a half-marathon (61.30%). Namely, both high weekly mileage and participating in a marathon were shown to be associated with an increased risk of a running related injury<sup>27</sup>. Also, different intercultural pain perception might explain to some extent the difference in the injury reporting prevalence of the authors' cohort in comparison to other national cohorts<sup>31</sup>.

In our study, the knee was the most commonly injured anatomic region (21.80%), followed by foot and ankle (8.60% both). Albeit with a somewhat higher proportion (34.70%), it was the most commonly injured region in novice runners in the analysis by Kluitenberg *et al.* Across published studies, the knee is consistently reported as the predominant site of running related leg injuries<sup>28</sup>. The exact factors that make the

knee most susceptible to injuries are not known, although it is plausible that it is due to the specific anatomy of the knee. Namely, the relative lack of highly adaptive tissues (muscles) makes the knee more sensitive to mechanical load<sup>29</sup>.

As expected, the mean BMI decreased and self-perceived health and fitness increased post-school as compared to baseline. Hespanhol Junior *et al.* report on a 3.30-kg reduction in body weight after one year of training. Weight reduction was comparable in our cohort (2.88 kg)<sup>30</sup>. Running has other beneficial effects on health indices, such as lipid profile improvement and resting heart rate reduction, therefore the subjects in our cohort experienced an overall improvement in self-perceived health.

Long slow distance was perceived as the easiest training session by 141 (40.40%) participants and fartlek as the most difficult one by 103 (29.50%) participants. To the best of our knowledge, there are no published results on training perception in novice runners. We believe that long slow distance training is perceived as being the easiest due to a steady slow tempo. On the other hand, fartlek is perceived as being the most difficult one due to intervals of high-intensity load.

There was a higher proportion of women among the non-injured runners (74.30% injured *vs.* 84.50% not injured). This finding is also consistent with the results of the previously published research, as females are known to have a lower risk of running related injuries<sup>27</sup>. Also, a lower proportion of fitness experience in injured *versus* non-injured runners is consistent with previous research findings<sup>6,32</sup>.

In conclusion, our results indicate that in order to reduce the incidence of running related injuries, organized running programs should focus less on preparing runners for a specific event, and instead introduce strengthening exercises, with particular focus on the knee.

A limitation of the study was not using objective diagnostic methods to assess injuries.

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## Sažetak

OZLJEDE LOKOMOTORNOG SUSTAVA U TRKAČA POČETNIKA:  
INCIDENCIJA, VRSTE OZLJEDA, VREMENSKI OBRASCI, SOCIODEMOGRAFSKI  
I MOTIVACIJSKI ČIMBENICI RIZIKA – PROSPEKTIVNA KOHORTNA STUDIJA*P. Vlahek i V. Matijević*

Cilj je bio istražiti incidenciju ozljeda lokomotornog sustava donjih ekstremiteta vezanih uz trčanje i utvrditi sociodemografske i motivacijske čimbenike rizika u trkača početnika tijekom osmomjesečnog programa škole trčanja. U istraživanje je bilo uključeno 349 trkačica i trkača koji su pohađali školu trčanja između siječnja 2011. i listopada 2014. Prikupljeni su podaci o sociodemografskim, antropometrijskim značajkama ispitanika, kao i oni o percipiranju vlastitog zdravlja, kondicije i motivacije za trčanje. Srednja vrijednost dobi kohorte je bila  $35,46 \pm 7,31$  godina, a 271 (79,5%) su bile žene. Ukupno su zabilježene 173 (49,9%) ozljede, s manjom učestalosti među ženama (42,9% prema 62,7%,  $p=0,016$ ; OR 0,878, 95% CI 0,788-0,977). Srednja vrijednost indeksa tjelesne mase je bila  $23,89 \pm 3,88$  kg/m<sup>2</sup> na početku i  $22,99 \pm 3,35$  kg/m<sup>2</sup> na kraju škole ( $p<0,001$ ). Medijan razine percepcije vlastite tjelesne kondicije je bio na vizualno numeričkoj ljestvici (1-10) 4 (interkvartilni raspon (IQR) 3-5) na početku i 8 (IQR 7-8) na kraju škole ( $p<0,001$ ). Medijan razine percepcije vlastitog zdravlja je bio 6 (IQR 5-8) na početku i 8 (IQR 7-9) na kraju škole ( $p<0,001$ ). Koljeno je bilo ozlijeđeno značajnije češće nego ostale anatomske regije ( $p<0,001$ ). Ispitanici su naveli želju za poboljšanje tjelesne kondicije kao najčešći razlog uključivanja u školu trčanja ( $n=159$ ; 45,7%). Zaključno, trkačima početnicima bi trebalo prije i tijekom trkačkog treninga uvesti vježbe za prevenciju ozljeda koljena.

Ključne riječi: *Trčanje – ozljede; Koljeno, ozljede; Donji ekstremiteti – ozljede; Rizični čimbenici; Ankete i upitnici; Vježbanje; Motivacija; Kohortne studije*