



STRESS FRACTURES IN ELITE FIGURE SKATERS

PRIJELOMI ZAMORA U VRHUNSKIH UMJETNIČKIH KLIZAČA

Sanda Dubravčić-Šimunjak^{1,4}, Harm Kuipers^{2,4}, Jane Moran^{3,4}, Marko Pečina⁵,
Ruben Ambartsumov⁴, Boris Šimunjak⁶, Hiroya Sakai⁴, David Mitchell⁴, Joel Shobe⁴

¹Department of Physical Medicine and Rehabilitation, General Hospital Sveti Duh, Zagreb, Croatia

²Department of Movement Sciences, Faculty of Health, Medicine and Life Sciences, University of Maastricht, The Netherlands

³University of British Columbia Faculty of Medicine, Vancouver, BC, Emergency Medicine and Sport Medicine, Victoria, B.C., Canada

⁴Medical Advisors, International Skating Union, Lausanne, Switzerland

⁵Department of Orthopaedic Surgery, School of Medicine, University of Zagreb, Zagreb, Croatia

⁶Sestre Milosrdnice University Hospital, ENT Department, Zagreb, Croatia

SUMMARY

The relationship between the occurrence of stress fractures, training parameters and nutritional regimes was assessed using an anonymous retrospective questionnaire in elite international level figure skaters representing all 62 member federations of the International Skating Union. The response rate was 62% in female and 67% in male figure skaters. Results were obtained from both junior and senior figure skaters (245 females and 167 males) with a median age of 16 yrs. for females and 18 yrs. for males. With regard to the subjects, 41 females (16.7%) and 25 males (13.8%) reported stress fractures in the last years of training and competing in figure skating. In female junior skaters, 75% of the reported stress fractures occurred in singles, 20.8% in pairs, and 4.2% in ice dancers. Among male junior skaters, 80% of the reported stress fractures occurred in singles, 13.3% in pairs, and 6.7% in ice dancers. In senior females, 70.6% of the reported stress fractures occurred in singles, 23.5% in pairs, and 5.9% in ice dancers, while among male senior skaters, 80% of the reported stress fractures occurred in singles, with 10% in pairs and in ice dancers. Regardless of the discipline, the majority of all stress fractures were located in the tibial bone. There was no difference between the incidence of stress fractures during summer or winter training, and this incidence was in no way related to dietary habits. All figure skaters attributed the occurrence of stress fractures to changes in their training and competition programs. In women, there was no statistically significant increased incidence of stress fractures in those with menstrual irregularities. Important factors that appear to contribute to the occurrence of stress fractures in elite figure skaters are increased physiological demands, including increasing rotations and height of jumps, as well as more rigorous training and competitive schedules throughout the skating season.

Key words: stress fractures, figure skating, training routine

SAŽETAK

Kod vrhunskih umjetničkih klizača promatrana je povezanost između pojave prijeloma zamora, parametara trenažnog procesa te prehrambenih navika. Anonimnim retrospektivnim upitnikom proveli smo istraživanje među svim članicama, njih 62, Međunarodne klizačke federacije. Povratnu smo informaciju dobili od 62% ženskih te 67% muških umjetničkih klizača. Rezultati su dobiveni od juniorskih i seniorskih vrhunskih umjetničkih klizača (245 ženskih i 167 muških), srednje životne dobi od 16 godina za žene i 18 godina za muške ispitanike. Prijelomi zamora pronađeni su kod 41 umjetničke klizačice (16.7%) i 25 umjetnička klizača (13.8%) koji su dijagnosticirani u posljednjim godinama njihovog treniranja i nastupanja. Kod ženskih juniorki 75% prijeloma zamora bilo je kod klizačica koje nastupaju samostalno, 20.8% kod sportskih parova i 4.2% kod plesnih parova. Kod muških juniora 80% prijelomi zamora javilo se kod klizača koji samostalno nastupaju, 13.3% kod sportskih parova i 6.7% kod plesnih parova. Kod seniorki, 70.6% prijeloma zamora javilo se kod onih koje samostalno nastupaju, 23.5% kod sportskih parova i 5.9% kod plesnih parova, dok se kod seniora 80% prijeloma zamora javilo kod onih koji samostalno nastupaju, a 10% kod sportskih te plesnih parova. Bez obzira na disciplinu umjetničkog klizanja, većina prijeloma zamora lokalizirana je na tibiji. Nije bilo razlike između pojave prijeloma zamora tijekom ljetnog i zimskog režima treniranja. Također nije pronađena korelacija između pojave prijeloma zamora i prehrambenih navika klizača. U žena nije pronađena statistički značajna razlika između povećane učestalosti prijeloma zamora i menstrualnih neregularnosti. Čimbenici koji najviše utječu na pojavu prijeloma zamora kod umjetničkih klizača povezani su s povećanim fizičkim naporima koji uključuju povećan broj rotacija i visinu kod pojedinog klizačkog skoka, povećanje količine napora tijekom pojedinog trenažnog procesa kao i povećan broj natjecanja tijekom jedne klizačke sezone.

Ključne riječi: prijelomi zamora, umjetničko klizanje, trenažni proces.

INTRODUCTION

Stress fractures are a relatively common diagnosis in sports medicine and are observed in many sport disciplines including figure skaters^{1,4,9,10,12,19,20,23}. Figure skating is a physically demanding sport that requires a unique combination of artistic ability, speed, agility, flexibility and power, which can only be achieved by progressive long-term training. The figure skating competitive season runs continuously for 8 months and may include various major International Competitions and Championships. During the last decades not only the competitive schedule has become tougher, but after introduction of the new judging system in 2003, also more emphasis is put on difficult technical elements, jumps, steps and spins^{27,28}. Therefore, the physiological and psychological demands on elite junior and senior figure skaters appear to have increased during the last few years.

It is likely that this does create more physical stress on the musculoskeletal tissues¹⁸. Because of this the incidence of acute and overuse injuries in figure skaters is likely to increase. This assumption is supported by a recent study about injuries among elite junior figure skaters by Dubravčić-Simunjak et al⁴. Unfortunately more studies about possible increasing incidence of stress fractures in figure skaters and contributing factors are lacking. Therefore the aim of this study was to obtain data about the current stress fracture cumulative risk among elite junior and senior figure skaters, as well as possible factors that may contribute to stress fracture incidence.

SUBJECTS AND METHODS

An anonymous questionnaire about the incidence of stress fracture among elite international level junior and senior figure skaters were mailed and distributed to all 62 International Skating Union (ISU) members through the ISU headquarters in Lausanne, Switzerland. Once filled out by skaters, the Member mailed it back to ISU headquarters where it was collected by the ISU Medical advisor, the first author of the article.

The guidelines of the Helsinki declaration 2004 were followed. In an accompanying paper the purpose of this inventory study was explained. It was clearly stated that all collected data were anonymous and could not be traced to any particular individual. Participation was strictly voluntarily, and the only burden on the participants was the time needed to fill out the questionnaire.

The questionnaire was divided into 5 sections:

1. General information - age, gender, height, weight, skating discipline, number of years skating, age at the time of first competition, landing foot and for female skaters questions related to menarche and menstrual irregularities
2. Stress fractures - specifying the site, time elapsed between the first pain and diagnosis, and methodology of diagnosis.
3. Stress fracture treatment
4. Training programs of individuals specifying the number of days and hours per week spent on on-ice and off-ice during summer and winter training.

5. Nutrition - in which we inquired about the regularity and frequency of meal consumption, eating disorders, use of food supplements and consumption of milk products.

Through this retrospective questionnaire we collected data about the incidence of stress fracture among elite figure skaters and tried to identify possible contributing factors. In order to obtain data as reliable as possible, the skaters were recommended to ask for assistance of coaches and / or medical doctors for filling in data about diagnostic procedures and injury treatment (e.g. was CT or MR done, or for how long were they away from practice...)

The collected data was stored in an Excel database and analyzed with descriptive statistics. χ^2 test was used to analyze possible differences between stress fracture incidence in females with or without menstrual cycle irregularities.

RESULTS

From the 644 skaters who received the questionnaire, 412 completed ones were obtained from 245 female and 167 male junior and senior international level figure skaters coming from different ISU members. The response rate was 62% in female and 67% in male figure skaters. The athletes were aged between 12 and 25 years with the majority between 13 and 19 years old. The median age for female skaters was 16 years and for males 18 years. Out of 245 female figure skaters 110 are juniors (78 single skaters, 12 pair skaters and 20 ice dancers) and 135 seniors (97 single skaters, 16 pair skaters and 22 ice dancers). Out of 167 male skaters 79 are juniors (47 single skaters, 12 pair skaters and 20 ice dancers) and 88 seniors (50 singles skaters, 16 pair skaters and 22 ice dancers).

All participants started to skate between 3 and 6 years of age and started to compete in national and international competitions when they were between 5 and 7 years old. At the time of this analysis, they had been skating between 9 and 20 years.

In 86.4% of all skaters the landing foot from jumps and throw jumps is the right one, while 13.6% of the skaters land on the left foot. All the stress fractures located in the tibia did occur in the landing leg. There was no relationship found between the landing foot and the occurrence of stress fractures at the other locations.

In females 41 (16.7%), and in males 25 (13.8%) figure skaters reported a stress fracture, which had occurred in the last years of their skating career. The distribution throughout the different figure skating categories and disciplines are shown in Tables 1 and 2. The site and the number of stress fractures in female and male junior and senior figure skaters throughout their skating disciplines are shown in Table 3 and Table 4.

After the onset of pain as the first symptom, bone scan, MRI or CT confirmed the diagnosis in 29 (70.7%) female and 18 (72%) male skaters. In 12 (29.3%) female and 7 (28%) male figure skaters the diagnosis was made with a standard radiograph, which was done 3-6 weeks after the onset of the first and initial pain and at which time the pain interfered with all skater's sports activities. All

skaters with a diagnosed stress fracture were treated with complete rest for a minimum of 2 weeks, but the majority rested between 4 and 8 weeks. None of the skaters required surgical intervention, but all skaters received various forms of physical therapy. The time for complete recovery varied between two and eight months.

Stress fractures and training characteristics

From all stress fractures reported, 21 (51%) occurred in females and 12 (48%) in male figure skaters during the competitive season, while 20 (49%) stress fractures in females and 13 (52%) in male figure skaters occurred during summer training. The distribution throughout the skating categories is presented in Table 5. Contributing factors, in absolute numbers and percentage that skaters associate with stress fracture occurrence are shown on Table 6.

Of the investigated skaters 93% trained almost all year round with a 1-2 month break, usually in May and June, after the end of a skating season, that runs from August from the current calendar year to April of the next calendar year.

The skaters generally train 6 days a week, both during summer and winter. They also participate in off-ice training 2-3 times a week in winter, and 3-5 times a week during summer training camps. They spent between 8 and 24 hours per week for on-ice training in winter and summer, while 1-10 hours per week were devoted to off-ice training during winter and 3-12 hours per week during summer time. There were no differences in training duration between the groups of skaters that did and did not report a stress fracture, but all skaters with stress fractures reported changes to their training routine before the occurrence of stress fractures.

Stress fractures, menstrual cycle and nutrition

Menarche in 203 (82.9%) female skaters occurred between 11 and 18 years of age with a median age of 15 years, while 42 (17.1%) female skaters aged between 11 and 16 years had not reached menarche at the time of the questionnaire. Among the 203 menstruating skaters, regular periods were reported in 19 females with a stress fracture, and in 112 skaters without a stress fracture. Irregular menstrual cycles were reported in 12 of the group with stress fractures and in 60 of the group without stress fractures. Among 42 female skaters who did not reach the menarche, 10 reported stress fracture in the last skating years. By χ^2 test we did not find statistically significant difference between the tested groups of skaters ($\chi^2 = 2.035$, $p > 0.05$ for two liberty percent).

Of the female skaters 18 (7.3%) reported changes in their weight and nutritional regime at the time the stress fracture occurred, while 5 (2%) skaters reported a growth spurt several months before the occurrence of the stress fracture.

In the male skaters 7 (4.2%) reported a growth spurt before the occurrence of the stress fracture.

In the female athletes 9 (3.7%) reported counseling for their nutrition, 44 (17.9%) are vegetarians and 192 (78.4%) of the female athletes consumed a varied diet including meat. Among male skaters, none of them reported counseling for nutrition, 8 (4.8%) are vegetarians

and 159 (95.2%) consumed a varied diet including meat. There is no significant difference in the nutritional regimes between questioned skaters with or without stress fractures. Of investigated skaters 356 (86.4%) female and male skaters used different kinds of food supplements throughout the year. In the female skaters 90 (44.1%) without a stress fracture and 19 (46.3%) with a stress fracture reported different kind of diets during the skating season in response to changes in their body weight. None of the male skaters reported any kind of diet during skating seasons.

None of female and male skaters reported use of laxatives or diuretics and none of them reported an eating disorder.

DISCUSSION

The overall prevalence of stress fractures in the present study was 16.7% in female and 13.8% in male figure skaters in the last years of their skating career. About stress fracture prevalence in elite figure skaters we reported in Letter to Editor in JSSM⁵ without analyzing possible contributing factors, what we represent in this article. The different cumulative risk among the figure skating disciplines can be explained by their different training patterns. Single skaters spend most of their training time practicing different double, triple and quadruple jumps and their legs suffer great impact during the whole training session. In pair skaters female counterpart has a higher stress fracture incidence than the male, whose rate of stress fracture is rather low, as in ice dancers. This may be caused by the fact that pair skaters not only do synchronous jumps but also use throw jumps where the female skater is thrown, while the men stays on the ice. Consequently the lower extremity of the female suffers repeated high impact during landing of different double or triple throw jumps that is not performed by the male counterpart. Pair skaters and ice dancers practice on different kind of team elements, unison and synchrony. Their lower extremities are less exposed to excessive repetitive impacts that occur during take off and landing from jumps, which are seen among single figure skaters^{4,18}. Numerous repetitions of different kinds of double, triple and quadruple jumps may be one of the major factors for increasing the cumulative risk of stress fractures in single figure skaters in the last decade. The large number of repetitions may induce the effect of fatigue on stress fracture injury risk during landing, which was confirmed by James et al¹⁵. According to Romani et al¹⁹, bone undergoes a normal remodeling process in physically active persons. Increased stress leads to an acceleration of this remodeling process, and may weaken the bone, which yields a higher susceptibility to stress fracture. In the past, when skaters spent the majority of training time on practicing compulsory figures, the number of different kind of triple jumps was much lower and the impact on lower extremity during practice was also lower. Twenty years ago elite female senior skaters won Olympic medals with only 2 or 3 different triple jumps, whereas nowadays the top 15 female skaters perform a minimum of 5 different triple jumps. In addition male skaters perform besides 5-6 different triple jumps

and one to two quadruple jumps^{27,28}.

Concerning the site of stress fractures, the major site was the tibia – in 58.3% of junior and in 58.8% of senior females and in 53.3% of junior and in 60% of senior male skaters with stress fractures, which is in line with previous studies^{3,4,19}.

All skaters with stress fractures eventually consulted a medical doctor, usually when the pain started to interfere with training. In all cases a qualified radiologist confirmed the diagnosis by MRI, CAT scan, bone scan, or standard X-rays, which are the standard diagnostic tools^{7,21,24}. It is important to stress that early and adequate diagnosis can shorten the time of rest, recovery and return to the sport as reported by Ivkovic et al¹¹. In our survey all 41 female and 25 male skaters with stress fractures returned “free of symptoms” to the pre-injury skating level 2-8 month after the diagnosis. The skaters in whom the diagnosis was delayed also needed a longer period of recovery.

Concerning possible contributing factors to stress fractures in our survey, all female and male figure skaters reported major changes in their training routine shortly before the occurrence of stress fracture. In most cases an excessive number of repetitions of jumps and throw jumps, during each training session (up to 30 repetition of each jump), was reported. Galilee-Belfer et al⁸ also reported that muscular fatigue and sudden changes in training intensity or duration may contribute to stress fracture incidence. In our survey we found that junior skaters (aged 13 to 19, and 13 to 21 for men pair skaters and ice dancers), who participate both in junior and senior events, are exposed to greater stress and impacts than juniors who only skate either in junior or senior competitions. Of all senior skaters with stress fractures 5.9% females and 10% males attributed the occurrence to the greater number of competitions and shows, while 20.8% of all female juniors and 33.3% of all male skaters felt that the large number of competitions and shows during one skating season contributed to the occurrence of stress fractures. This is a novel and relevant finding which may have to be taken into account for developing the competition schedule. Reeder et al²¹ emphasized the importance of overload for stress fracture development, and Loud et al¹⁷ described the correlation between the occurrence of stress fractures and time spent on vigorous or moderate sports activity in females under 17 years of age. They reported a greater number of stress fractures in girls who trained over 16 hours per week compared to those who train less than 16 hours per week. From the results of the present retrospective study it was found that skaters, juniors and seniors, associated the appearance of stress fractures with excessive load of lower extremities during training and competitions either by increasing training hours, during which they spend more time in practicing different kinds of triple and quadruple jumps, or by other changes in the training programs or by greater number of competitions and shows during one skating season.

Concerning a possible contributing role of nutritional factors we found that 46% of female skaters

with stress fractures and 44% without stress fracture did report different types of dietary patterns throughout the skating season in order to obtain adequate body weight. Although in the present study there were no indications suggesting dietary factors or for the female athlete triad, it has to be acknowledged that a questionnaire may be biased by under reporting. Therefore the actual number of skaters with eating disorders may have been higher than found in this survey. Several authors have reported that the female athlete triad is a significant contributor to the incidence of stress fractures in female athletes^{2,14,16,17,26,29}. Ziegler et al^{30,31} discussed dietary behavior and nutritional status in young figure skaters, and showed that figure skaters may diet despite satisfactory body image. They also point to the need for nutritional education for figure skaters, especially during their competitive season when nutritional status may be compromised. 86.4% of our tested skaters take food supplements consisting of multivitamins and multiminerals with adequate consumption of milk products and eating habits, which is in line with data from Ziegler et al³² in US figure skaters.

Among the 245 female skaters in the present study 42 (17.1%) aged between 11 and 16 were still pre-menarche at the time of the questionnaire completion. There was no statistically significant difference between the groups of skaters with menstrual irregularities and the occurrence of stress fractures. Different findings were reported by Kelsey et al¹⁵ in female cross country runners, who find statistically significant difference between the tested groups.

Because the accuracy of the data obtained by questionnaire may be limited^{6,25} we strongly recommended the athletes to include a medical doctor and /or coach for precise and accurate filling out the survey.

CONCLUSION

In conclusion the data suggest that the cumulative risk of stress fractures is increasing in figure skating, especially among single figure skaters and female pair skaters. In the light of increasing physiological demands from rigorous training and competitive schedules throughout the skating season, prevention deserves more emphasis. Proper education to athletes and coaches about training regimes, nutrition and early recognition of stress fracture symptoms may help to decrease the stress fracture risks. Because of the large number of competitions and shows in a short period of time, it is recommended to critically review the competitive schedule. In addition, rule changes concerning the ages and skaters possibilities to compete in both senior and junior Events may have to be considered.

ACKNOWLEDGEMENTS

The authors thank the ISU headquarters in Lausanne, Switzerland for the assistance and support in questionnaire distribution. There was no financial assistance with the project.

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