Does long-term recreational gymnastics prevent injurious falls in older women? A prospective 20-year follow-up

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Research article

Keywords: exercise, physical activity, falls, fractures, older women

Posted Date: October 24th, 2019

DOI: https://doi.org/10.21203/rs.2.16435/v1

Version of Record: A version of this preprint was published on February 1st, 2020. See the published version at https://doi.org/10.1186/s12877-020-1428-0.

Abstract

Background : Exercise interventions focused on balance and strength training have been shown to be effective for falls prevention. The aim of this 20-year register-based follow-up was to examine whether long-term participation in recreational female gymnastics is associated with a lower risk of medically-attended injurious falls.

Methods : Health care register data of 187 women (103 recreational gymnasts and 84 sedentary controls) from the original cohort of 243 women were assessed. The mean age (sd) at baseline was 62.8 (5.4) years and the mean follow-up time was 19.4 (2.7) years (range from 5.6 to 21.0 years). Injurious falls were scrutinized from medical records. An injurious fall was defined as an event in which falling was mentioned as a reason for making contact with the health-care professionals. Negative binomial regression was used to estimate incidence rate ratios (IRR) for injurious falls, and Cox-regression models for calculating hazard ratios (HR) for injured fallers with the control group as reference.

Results Recreational gymnasts had about 30% less injurious falls compared to controls, the mean IRR (95% CI) being 0.71 (0.51 to 0.96). Regarding injured fallers, the HR was 0.73 (0.52 to 1.02) favoring the recreational gymnasts. There were no statistically significant between-group differences for fractures.

Conclusions: Long-term recreational gymnastics appears to reduce the risk of injurious falls in old age.

Background

Falls in older adults are a major economic and public health concern, and ageing of the population further escalates the expenses involved. Falls and fear of falling can reduce physical activity and functional capacity, impair the ability to perform daily activities, reduce quality of life, and increase the risk of social isolation and institutionalization [1, 2].

Focusing on strategies reducing the risk of falls and related injuries in the older population would not only decrease pain and disability but also reduce the costs to society significantly [3]. Even if the incidence of falls and fall-related injuries were to remain stable, absolute numbers of such injuries would continue to rise because the number of people living into older age is increasing; centenarians are no longer unusual [4].

History of falls is a strong indicator for increased risk of fractures [5], and thus reducing falls is crucial in the prevention of injurious falls and fractures in the older population [6]. Epidemiologic evidence suggests that physical activity is beneficial in reduction of fragility fractures [7-9], and exercise training has been found to be the single most effective way to prevent falls and related injuries in community-dwelling older people [10-13]. Therefore, it is important to raise awareness of older adults about their individual fall risk and motivate them to stay physically active and exercise regularly. Balance and functional training, as well as multicomponent exercise comprising of balance and strength training have been shown to be

most effective preventive measures [11-13]. Moreover, both group and home-based training interventions have turned successful [14-17].

We have previously shown that long-term regular participation in recreational gymnastics was associated with better overall physical fitness through improved muscle performance, agility and balance among postmenopausal women. Recreational gymnastics was also positively associated with greater bone mass and bone strength especially in the weight-bearing lower limbs [18, 19].

In this 20-year follow-up study we used the same female cohort to assess whether older women who had been engaged in recreational gymnastics for decades differed from their sedentary counterparts in terms of medically-attended fall-related injuries.

Methods

Participants

At baseline, all participants were healthy, postmenopausal, non-smoking women aged from 55 to 83 years. Recreational gymnasts and folk dancers were recruited from local clubs while sedentary controls were obtained via a local newspaper advertisement. Exercising women had trained at least 20 years in recreational gymnastics or folk dance. Any who had competed in apparatus gymnastics at any age were excluded from the original study [18]. Women who participated no more than once a week in light or moderate exercise, that was not gymnastics or folk dancing were eligible as sedentary controls [18].

Shortly described, recreational female gymnastics is light to moderate in intensity and emphasizes springy gait and body flexibility. It also includes more strenuous exercise causing elevation of heart rate and including muscular strength training, but it does not have any high impact training as is common in standard aerobics or apparatus gymnastics. Finnish folk dancing is, in turn, aerobic dancing with brisk turns and light jumps that create low to moderate impact. Women who practiced in folk dancing were also active in recreational gymnastics. The above described training is referred as recreational gymnastics in this report.

The participants' history in recreational gymnastics was determined for 10-year periods from the age of 16 to 45 years, and for 5-year periods thereafter (average duration of one session, number of sessions a week, training months a year, and training years in each period). The controls answered the same questions in order to verify that they fulfilled the selection criteria of the study.

The primary outcome of the present study was the rate of medically-attended injurious falls including fractures during the 20-year follow-up period. In addition, fall-induced fractures and the rate of injured fallers and fallers with fractures were evaluated as secondary outcomes.

From the original cohort of 243 women, 187 (77%, 103 recreational gymnasts and 84 sedentary controls) were included in this register-based follow-up study. The health care register data was unavailable for 49 women (18 gymnasts and 31 controls), since they lived outside of Tampere, and we did not have access to their personal health data. Also, records of seven women who died had been deleted after expiry of the archive storage time. For all the remaining women the follow-up time was calculated from baseline to the 20 years (148 women), or to the date the participant had moved out the area (5 women) or died (34 women) (Figure 1).

The study protocol was approved by the Human Ethics Committee of the Tampere Region, University of Tampere, Finland (approval 53/2017). The use of the patient-register data was further approved by the Department of Social Services and Health Care of the City of Tampere.

Add Figure 1 here

Methods

This 20-year follow-up was conducted for all women who were still living in Tampere and had participated in the original study in 1997 [18]. The Pegasos patient medical records of the City of Tampere (Pegasos Patient Information System, CGI, Finland) were scrutinized for fall-related health services utilization including hospitalizations for all participants during the follow-up period starting from September 1997 to April 2018; the years between 1997 and 2002 were manually examined from paper files, while more recent data was available in digital format.

Medically attended fall injuries were defined according to medical care and conformed to a recommended definition of a fall [20], and included injuries that have required medical/health professional examination, or emergency/inpatient treatment, regardless of the severity of injury [21].

All contacts with the local Finnish health care system mentioning “fall”, “fall-related”, or “fall-injury” as reason for the contact were recorded. Injurious falls included injuries, such as bruises, abrasions, contusions, sprains, fractures, and head injuries. An injured faller was defined as a person who had contacted the health care system at least once due to a fall during the 20-year follow-up period. Information concerning the original study group assignment was added to the data only after all injurious falls were recorded.

This 20-year follow-up focused solely on medical records without any personal contact with the former participants.

Statistical analysis

Follow-up time for injurious falls and fallers was calculated from the baseline (September 1997) to the end of the follow-up period (April 2018).

Injurious fall incidence rates were calculated as the total number of falls divided by the time over which injurious falls were monitored in both groups. Negative binomial regression was

used to estimate incidence rate ratios (IRR) for injurious falls and fracture falls, and Cox-regression models for calculating hazard ratios (HR) for injured fallers and fracture fallers using the control group as reference. All analyses were adjusted for baseline age, height and weight as possible confounding factors. All non-significant confounders were removed one by one from the final models if their p-values exceeded 0.20. Negative binomial regression models were also adjusted for follow-up time.

SPSS 25 statistical software was used for all statistical analyses. P-values were 2-sided and those less than 0.05 were considered statistically significant.

Results

The baseline group descriptions are given in Table 1. The recreational gymnasts were slightly older and lighter than the controls. The follow-up comprised data for 187 of the original 243 women (77%). The mean (sd) follow-up time was 19.4 (2.8) years ranging from 5.6 to 21.0 years, totalling to 3635 person-years. Clinical characteristics of 56 women with no follow-up data did not differ from the 187 included women.

Add Table 1 here.

During the 20 years follow-up, 378 injurious falls were recorded among 135 (72.2%) women. Forty-seven (25.1%) women sustained a single injurious fall, 33 women (17.6%) had two injurious falls and 55 women (29.4%) had three or more injurious falls. About a third of the women sustained a fracture as a consequence of falling (Table 2).

Add Table 2 here.

Recreational gymnasts had nearly 30% less injurious falls than controls; incidence rate ratio (IRR; 95% CI) 0.71 (0.52 to 0.96). However, the between-group difference in fall-induced fractures was not statistically (Table 2). The Cox model showed a 27% lower rate of injured fallers in recreational gymnasts than in controls (HR 0.73; 0.52 to 1.02), but the risk was opposite in fracture-fallers. However, these differences were not statistically significant (Table 2, Figure 2). Recreational gymnasts were on average four years younger than sedentary controls when they sustained their first fracture.

Add Figure 2 here.

There were 67 fallers with 113 fractures. The most common fractures were upper limb fractures (33 in recreational gymnasts and 15 in controls), while the most severe hip fractures occurred equally in both groups (6 in each). Head injuries were also quite common, 61 head injuries including two facial fractures required medical attention. Severe fall-induced injuries are compiled in Table 3.

As a sensitive analysis, the above analyses were repeated in age-based tertiles and the results were in line with the above-described results based on the entire group (data not shown).

Add table 3 here.

Discussion

There was a clear, statistically significant difference in medically-attended injurious falls between the recreational gymnasts and controls, the former having about 30% less injurious falls during the 20 years follow-up. However, the 27% between-group difference in injured fallers did not quite reach statistical significance. Concerning fractures and fallers with a fracture, there was no significant group difference either.

Previously, clinical trials have shown that resistance and balance training reduces the risk of falls, especially that of injurious falls [10, 11]. In their recent Cochrane-review, Sherrington et al. reported that exercise reduced the rate of falls by 23% on average. Most effective exercise programs primarily comprised balance and functional exercises, while programs including multiple exercise categories (typically balance and functional exercises, as well as resistance exercises) may be beneficial as well [13]. Our results are in line with these remarks.

We have shown previously that exercise training can reduce the severity of falls [22]. This benefit was partly maintained after cessation of the exercise intervention, despite the fact that physical activity had returned to baseline and did not differ from the non-training counterparts anymore [23-25]. However, all exercise trials do not support a reduction in falls incidence [26, 27]. The heterogeneity of the training programs used (type, intensity, frequency and duration of the program), as well as the participant characteristics, their adherence and compliance with the training program may explain the discrepancies.

Although the recreational gymnasts had less injurious falls in general, they showed a trend for more upper limb fractures. Although this may seem perplexing, this finding is not unique. Physical activity was associated with a reduced risk of hip fractures in the SOF-study, but the risk of wrist fractures was slightly increased among physically active older women [28]. In the Tromsø study, high rates of physical activity were related to a 50% increased relative risk of upper limb fractures [29]. Also, a long-term follow-up study of a Finnish cohort suggested more wrist fractures among physically active postmenopausal women compared to inactive women of similar age [30]. Frequent walking has been associated with increased risk of fractures among older adults [31], but active commuting among middle-aged women was associated with a lower wrist fracture risk [32]. A recent meta-analysis of RCTs examining exercise and the fracture risk showed that exercise is generally related to reduced fracture risk [33].

As discussed previously [28, 29], some explanations for the increased risk of upper limb fractures in physically active older persons may be debated. Recreational gymnasts were more agile at baseline and six years later, and this benefit may have been maintained in older age. Thus, when slipping or tripping, recreational gymnasts had time to extend their arm to absorb the impact energy resulting in more wrist fractures in place of other injuries, such as hip fracture or head injury. Having a feeling of good performance may also predispose not only to higher exposure time of physical activity [32], but also to higher walking speed and more risky behavior. Moreover, when stumbling at faster gait speed the impact force in falling is likely greater and possibly sufficient to fracture the upper limb bones. In this study, recreational

gymnasts were about 4 years younger than sedentary controls when sustaining the fall-induced fracture, which may support the notion of faster walking speed while falling.

The strengths of this study are a long follow-up time, and comprehensive evaluation of participants' specific history in recreational gymnastics (determined in 10-year periods from the age of 16 to 45 years, and 5-year periods thereafter including duration and number of sessions a week, training months and years). The controls answered the same questions to verify that they were eligible for the study as proper controls. In addition, injurious falls were verified from medical records, which increased the reliability of the data. The types of injuries and the treatment provided were well described including the most severe traumas with exact ICD-codes, but the site of the fall (e.g. outdoors/indoors) or circumstances were not always mentioned.

One limitation of the study is that while the recreational gymnasts had exercised on average of 33 years at baseline in 1997, we had no information about their physical activity, participation in gymnastics, physical performance or mobility status after the 6-year follow-up in 2003. It can be expected that both physical activity and physical performance declined with aging or chronic diseases or other incident health or social issues, but we have no measured data to support this phenomenon. Physical activity was not recorded systematically in medical records, let alone physical performance or functioning. We decided not to invite the former participants to the 20-year follow-up measurements because it was expected that only the women in good physical condition would have been able to participate, and this would have biased the analyses.

Another limitation is that medical records were available only for the women living in City of Tampere, and who had contacted the public health care system due to injuries. It is possible that some women may have sought treatment from private health care services. However, in Finland, senior citizens after retirement remain no longer under the domain of occupational health care but fall within the public health care service system. Practically all 52 women with no mention of an injurious fall in their medical records had contacted the public health care system for some other health reason. Some injurious falls were treated elsewhere when travelling, but the aftercare was carried out in the local health care center or hospital, and these cases could be counted. Also, because we did not have access to medical records of surrounding municipalities, we had to exclude the women living in these neighborhoods. In addition, records of 7 deceased women had already been deleted. However, missing these women's information was not likely alter the findings because women with and without available register data were similar in their baseline characteristics, and the proportion of missing data (23%) was relatively small.

Also, we had no information about falls which did not require contact with the health care system. Most likely, these occurrences were falls with no consequences, or they resulted in mild injuries causing no long-term harm, disability or pain, and therefore the person did not consider it necessary to visit a health center to see a physician. We had permission only to access fall-related injurious data, not to the other health data, e.g. diseases or medication during the follow-up. Although all participants were relatively healthy at baseline, the

possibility that within-group changes in health status were not similar cannot be ruled out and result is biased. It is well known that higher physical activity and fitness are associated with better health status in general. Further, at baseline about half of the participants used estrogen replacement therapy, but there was no difference in injurious fallers between previous estrogen users and non-users. Estrogen was not associated with physical functioning at baseline either, but was associated with greater bone mass [18, 19]. However, users of estrogen replacement therapy were equally divided into both groups.

Although the health benefits of regular physical activity are well established, poor exercise adherence and compliance with physical activity recommendations is very common in the elderly population [34]. On the other hand, long-term physical activity at younger age predicts physical activity at old age [35]. Also, in intervention trials, the adherence and compliance remain fairly good as long as the training is supervised, but after the intervention, the adherence to physical activity unfortunately tends to return to the baseline. The benefit of recreational gymnastics is that it is offered by several clubs with low semester costs and exercise sessions are held in residential areas, making the training easily accessible, feasible and safe to perform. Despite being light to moderate by intensity, long-term regular participation may compensate for the benefits of more intensive training, which often is discontinued after a short period.

Conclusions

Long-term light-to-moderate intensity exercise with muscle strength, balance and mobility training seems to reduce the risk for medically-attended injurious falls in older age.

Declarations

Abbreviations

IR, incidence rate ration; HR, hazard ratio; CI, confidence interval

Authors' Contributions

Study concept and design: KU-P, SK. PK and HS. KU-R was responsible for collecting the data. Data analysis: KT and KU-R. Writing of the manuscript: KU-R, SK, PK, KT and HS. All authors read and approved the final manuscript.

Funding Sources

No external funding.

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 interest

The authors declare that they have no conflict of interests to disclose.

Consent for publication
Not applicable.

Ethics approval
This 20-year follow-up focused solely on medical records without any personal contact with the former participants. All procedures performed in the studies involving human participants' register data were in accordance with Office of the Data Protection Ombudsman. Risk evaluation has been carried out in accordance with EU data protection regulation and the Finnish data protection act (1050/2018). The study protocol was approved by the Human Ethics Committee of the Tampere Region, University of Tampere, Finland (approval 53/2017)) and conducted in accordance with the Helsinki declaration.

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Acknowledgements
Not applicable

Tables

Table 1 Group Characteristics, mean (SD)

	Sedentary controls n=84	Recreational gymnasts n=103	All n=187	Missing cases n=56
Age at baseline 1997, years	62.1 (4.6)	63.3 (5.9)*	62.8 (5.4)	62.3 (5.2)
Height at baseline, cm	161.4 (5.8)	160.8 (5.2)	161.1 (5.5)	162.2 (5.3)
Weight at baseline, kg	68.4 (10.4)	66.7 (9.6)*	67.5 (10.0)	67.6 (9.9)
BMI	26.3 (3.8)	25.8 (3.5)	26.0 (3.6)	25.7 (3.3)
Age at register 2018, years	81.3 (5.1)	82.8 (5.6)	82.1 (5.4)	
Follow-up time, years	19.3 (3.1)	19.6 (2.4)	19.4 (2.7)	
Range of follow-up, years	5.6 – 20.7	9.3 – 21.0	1. – 21.0	

*p <0.05

Table 2 Injurious falls and injured fallers between 1997-2018, and rate of injurious falls, incidence rate ratio (IRR) and hazard ratio (HR) adjusted for age, height and weight at baseline (95% CI).

	Sedentary controls n=84	Recreational gymnasts n=103	All n=187
All injurious falls, n	194	184	378
All injurious falls/10 years	1.20	0.91	
All falls with fractures	39	63	
All falls with fractures/10 years	0.24	0.31	
Age at first injurious fall, years	72.0 (6.4)	72.7 (8.1)	72.3 (7.3)
Non-Faller, n (%)	17 (20.2)	35 (34.0)	52 (27.8)
Injured faller, n	67 (79.8)	68 (66.0)	135 (72.2)
Faller (1 fall)	23 (27.3)	24 (23.3)	47 (25.1)
Faller (2 falls)	14 (16.7)	19 (18.4)	33 (17.6)
Faller (multiple falls)	30 (35.7)	25 (24.3)	55 (29.4)
Fallers with fractures, n (%)	29 (34.5)	38 (36.9)	67 (35.8)
Fallers with 1 fall resulting fracture	24 (28.6)	25 (24.3)	49 (26.2)
Fallers with 2 falls resulting fractures	2 (2.4)	7 (6.8)	9 (4.8)
Fallers with multiple falls resulting fractures	3 (3.6)	6 (5.8)	9 (4.8)
Age at first fracture, years	76.2 (6.8)	72.4 (7.5)	74.1 (7.4)
IRR (95% CI)			P-value
All injurious falls	1	0.71 (0.52 to 0.96)	0.026
Falls with fractures	1	1.32 (0.81 to 2.17)	0.27
HR (95% CI)			
All injured fallers	1	0.73 (0.52 to 1.02)	0.068
Fallers with fractures	1	1.16 (0.72 to 1.89)	0.54

Table 3 Fractures and head injuries caused by falls, n (%)

	Sedentary controls n=84	Recreational gymnasts n=103	Total n=187
Hip/pelvic area	6 (7.1)	6 (4.6)	12 (6.4)
Upper limb (wrist and humerus)	15 (17.9)	33 (32.0)	48 (25.7)
Lower limb (tibia, fibula and ankle)	2 (2.4)	7 (6.8)	9 (4.8)
Spine	5 (5.9)	5 (4.9)	10 (5.3)
Clavicle and rib	3 (3.6)	2 (1.9)	5 (4.9)
Metacarpals and Phalanges	3 (3.6)	6 (5.8)	9 (4.8)
Metatarsals and toe bones	1 (1.2)	0	1 (0.5)
Facial bones	1 (1.2)	1 (1.0)	2 (1.1)
Head injuries (including swellings and bruises)	28 (33.3)	31 (30.1)	59 (31.6)

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Figures

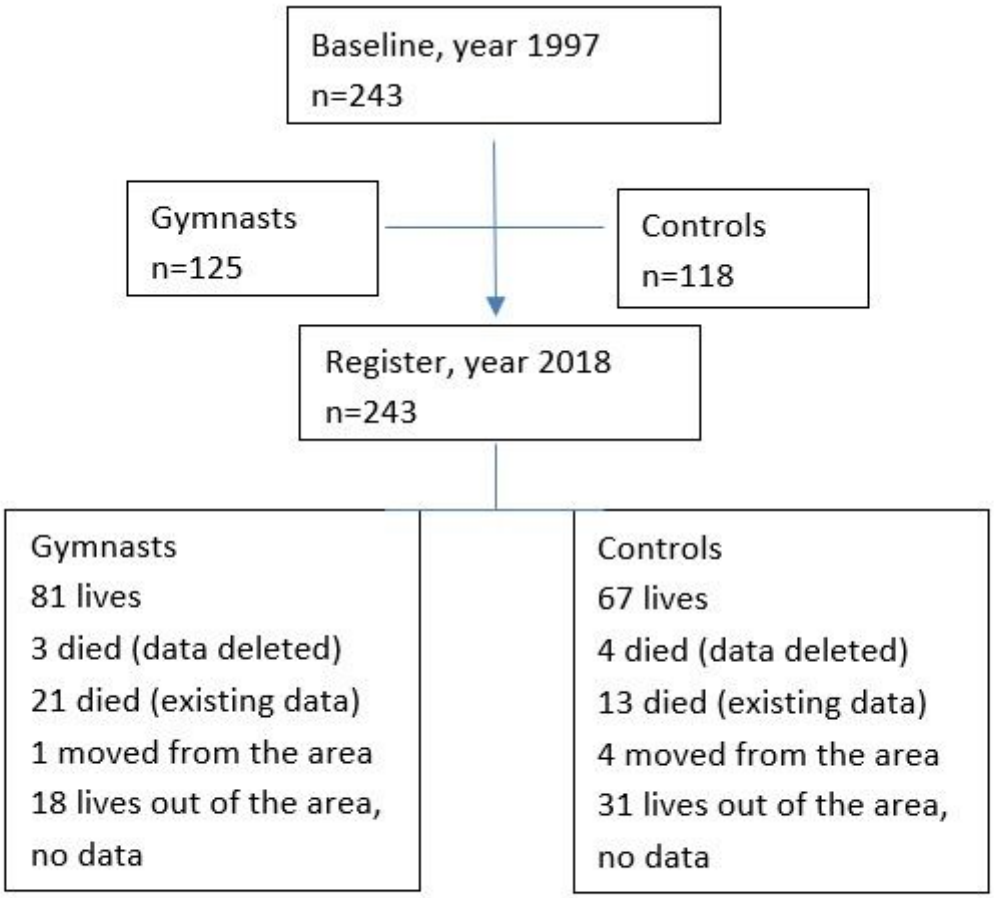
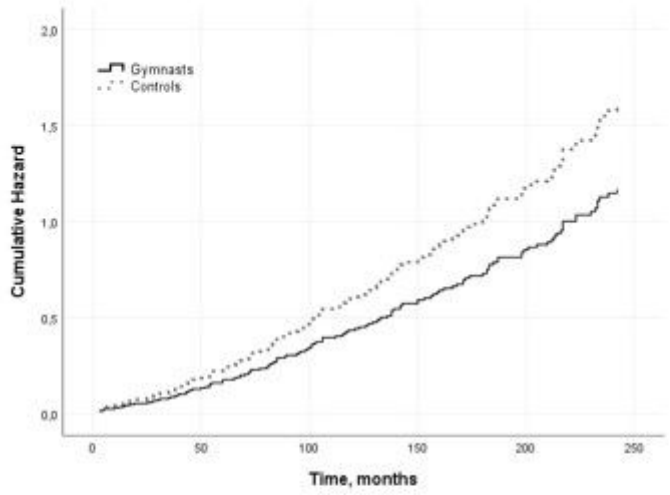


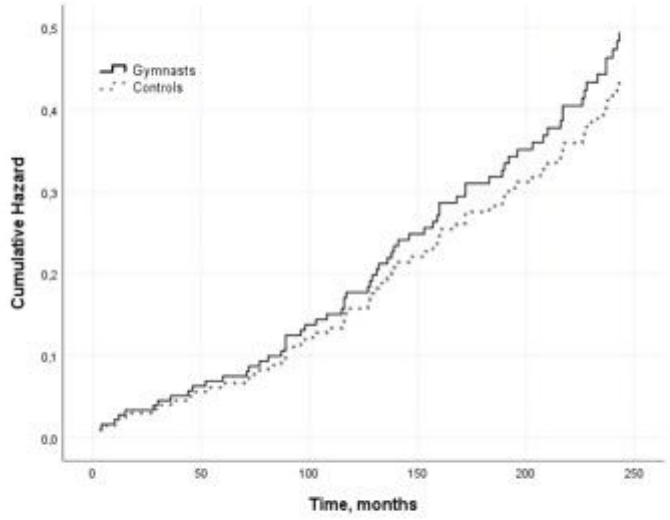
Figure 1 Flow chart

Figure 1

Flow chart of the study.



Panel a.



Panel b.

Figure 2

Hazard ratio for injured fallers (panel a) and for fallers with fractures (panel b) among recreational gymnasts and sedentary controls.