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Active Living and Injury Risk

Abstract

The purpose of this study was to get reliable insight into injury risk in various commuting and lifestyle activities, as well as recreational and competitive sports. A cohort of 3657 persons was randomly selected from the 15- to 74-year-old Finnish population. Ninety-two percent (n = 3363) of the subjects accepted to participate the one-year follow-up, record all their physical activities that lasted 15 min or more, and register all acute and overuse injuries that occurred during these activities. To collect the information, the study subjects were interviewed by phone by the trained personnel of the Statistics Finland three times in four-month intervals. The individual injury risk per exposure time was relatively low, ranging from 0.19 to 1.5 per 1000 hours of participation, in commuting and lifestyle activities including walking and cycling to work, gardening, home repair, hunting and fishing, and, in sports such as golf, dancing, swimming, walking, and rowing. The risk was clearly higher in squash, orienteering, and contact and team sports, such as judo, wrestling, karate, rinkball, floorball, basketball, soccer, ice hockey, volleyball, and Finnish baseball ranging from 6.6 to 18.3 per 1000 hours of participation. However, the highest absolute number of injuries occurred in low-risk activities, such as gardening, walking, home-repair, and cycling, because they are performed so often. In conclusion, individual injury risk per exposure hours is relatively low in commuting and lifestyle activities compared to many recreational and competitive sports. However, at a population level, these low-to-moderate intensity activities are widely practised producing a rather high absolute number of injuries, and thus, preventive efforts are needed in these activities, too.

Key words
Epidemiology · exposure time · individual injury risk · leisure-time injury · sports injury · injury prevention

Introduction

The increasing promotion of leisure-time physical activities among the general public for reducing the risk of chronic diseases [2,5,9,13,17,19,29] should rise a question about the possibility of accompanying injuries and other adverse effects [3,14,25]. Since treating the activity-related injuries is a true public health burden preventive strategies and activities are justified on both medical as well as economic grounds [3,10,14,20,25,28].

Before initiating a measure or program for preventing injuries, the extent of the problem must, however, first be defined [20,30]. Several epidemiological surveys have outlined the frequency and severity of injuries in various sports, but epidemiological knowledge of injuries among commonly practised low-to-moderate intensity, non-competitive activities (commuting, lifestyle, recreational, and fitness activities) is surprisingly sparse. Moreover, direct comparison of injury rates between different studies and activities is complicated by many methodological differences [12,15,22,24]. A prospective approach that

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follows a large group of participants through different types of activity allows good comparisons of injury risks between various activities [24].

The purpose of this prospective cohort study was to get reliable insight into risk and severity of injuries in various commuting and lifestyle activities, as well as recreational and competitive sports in Finland, a country with a well-defined Caucasian population of 5.2 million.

Material and Methods

A population-register based random sample of 4100 persons was selected from all 15- to 74-year-old Finns. All were approached by telephone and those subjects who could be reached (n = 3 657) received a letter where their willingness to participate in the one-year follow-up study was inquired. Ninety-two percent (n = 3363) of these subjects accepted the invitation and agreed to report their physical activities and related injuries during the course of the study. The study was approved by the Ethics Committee of the UKK Institute and the subjects gave a written informed consent before the initiation of the study.

To collect information, the study subjects were interviewed by phone by the trained personnel of the Statistics Finland, the Central Statistical Office of Finland, three times in four-month intervals. During these interviews the exposure time to different activities (i.e., the frequency and average time spent in each activity) was recorded with a structured computerised questionnaire. Previously validated population questionnaires were modified to include a full coverage of different types of activity (commuting activities, lifestyle activities, and recreational and competitive sports) [7,27]. Injury was defined as a new acute trauma or overuse injury that caused a significant complaint to the subject. The severity of the injury was classified into 3 levels according to Requa and Garrick [24] (Table **1**). In addition, the time of the injury occurrence, and the place, cause, type, and location of the injury were registered via the structured computerised questionnaire.

The injury incidence rate was expressed as the average number of injuries per 1000 person-years, per 1000 active persons at risk (active cohort), and per 1000 hours of exposure. For the latter, the 95% confidence interval was also calculated. The incidence rates were calculated separately for each activity, and, for men and women in the age groups of 15 – 24, 25 – 34, 35 – 44, 45 – 54, 55 – 64 and 65 – 74 years, in three main categories of leisure-time physical activity (commuting activity, lifestyle activity, and recreational and competitive sports). The recreational and competitive sports were also analysed in the three subgroups which included following activities: "Endurance sports" included cycling, dancing, horse riding, inline skating, orienteering, pole walking, rowing, running, skating, swimming, X-country skiing, and walking; "Team sports and ball games" included badminton, basketball, Finnish baseball, floorball, golf, ice hockey, rinkball, soccer, squash, tennis, and volleyball; "Power and contact sports" included gym training, gymnastics, downhill skiing, judo, karate, track and field sports, and wrestling. Statistical significance level for age and sex differences in different types of sports were analysed by Poisson regression model.

Table **1** Definition of the severity of the injury [24]

Level	*Time lost*	*Description*
Level I	No	Injury or pain not affecting sports or other leisure-time physical activity, or, only modified duration or intensity of the activity without missing any activity session
Level II	Yes	Injury or pain resulting in missing of a sports or other leisure-time physical activity session at least once
Level III	Yes	Injury or pain resulting in missing of work or corresponding activity at least for one day

Results

The drop out rate during the one-year follow-up was 9%. During the one-year study period, a total of 1867 injuries were reported among 3055 study subjects (1033 injuries among 1462 men and 834 injuries among 1593 women). Five percent of the injuries occurred in commuting activities, 22% in lifestyle activities, and 73% in recreational and competitive sports. Participation of 15- to 74-year old Finnish population to different modes of commuting and lifestyle activities, and recreational and competitive sports and the total number and risk of injury in various activities are shown in Table **2**.

A high absolute number of injuries occurred in leisure-time activities such as gardening, walking, home-repair and cycling, due to their frequent participation in the population (Table **2**). However, the individual injury risk per exposure time was relatively low in all commuting and lifestyle activities and in some sports events, such as golf, dancing, swimming, walking, and rowing. In these, the injury risk ranged from 0.19 to 1.5 per 1000 hours of participation (Fig. **1** and Table **2**). Injury risk was highest in squash, orienteering, and contact and team sports, such as judo, wrestling, karate, rinkball, floorball, basketball, soccer, ice hockey, volleyball, and Finnish baseball ranging from 6.6 to 18.3 per 1000 hours of participation (Fig. **1** and Table **2**).

In both commuting and lifestyle activities, the overall injury risk per exposure time was somewhat higher in women than in men. In recreational and competitive sports, an overall injury risk was higher in men (Table **3**). However, in endurance sports women had somewhat higher injury risk than men (Table **4**). In recreational and competitive sports, the injury incidence decreased by age: in 15 – 24-year-old men and women, the injury incidence rates were 4.2 and 3.1 per 1000 hours of participation, while in 65 – 74-year-old persons the corresponding figures were 1.0 and 1.2, respectively (Table **3**).

Injury severity varied between the activities so that in home repair, gardening, dancing, swimming, cross-country skiing, pole walking, cycling, downhill skiing, motor sports, inline skating, karate, ice hockey, floorball, orienteering, judo and squash majority of injuries were Level I injuries, while commuting activities, track and field sports, volleyball, ice hockey and wrestling also produced a considerable number (> 20% of all) of Level III injuries (Table **5**). Fifty-eight percent of injuries that occurred in

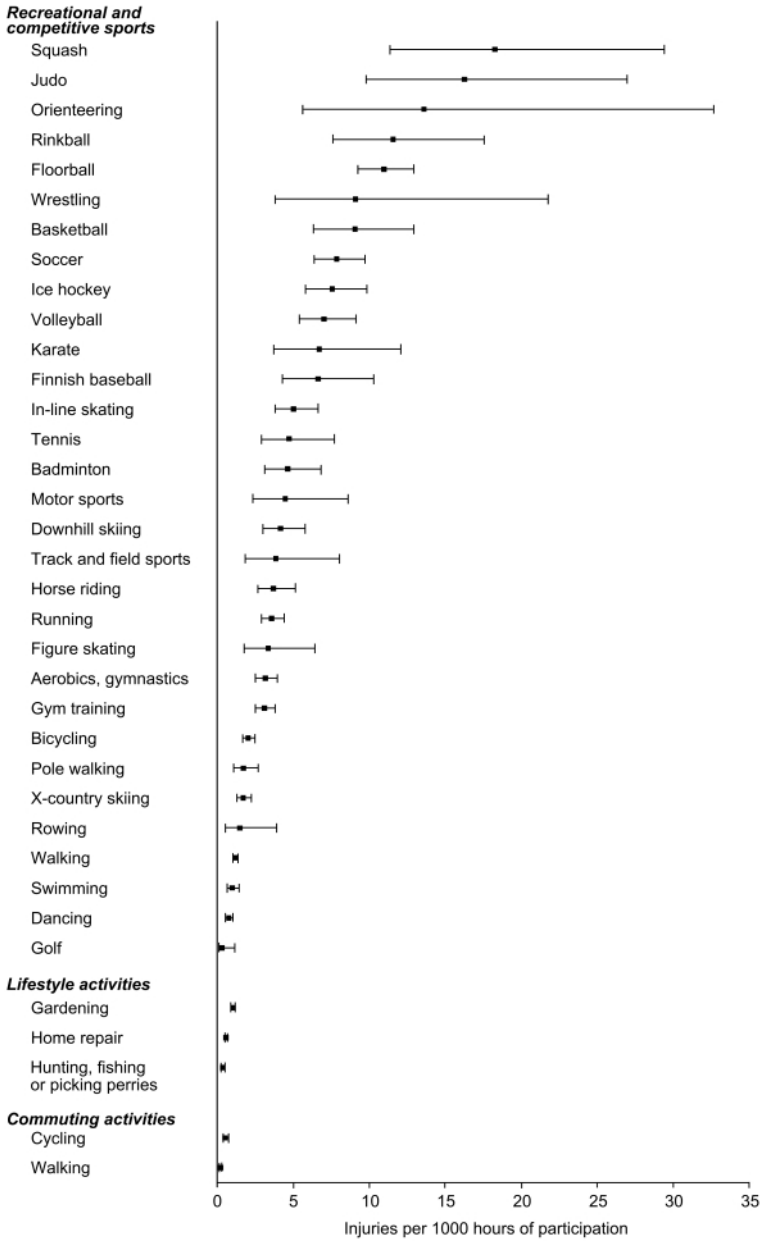

Fig. **1** Number of injuries per 1000 hours of participation in various recreational and competitive sports, and lifestyle and commuting activities (bars represent 95% confidence interval).

commuting activities caused time loss from physical activity or work, the similar figures being 43% and 52% in lifestyle activities and recreational and competitive sports, respectively (Table **5**).

Discussion

This one-year prospective cohort study followed, for a first time, a large population sample with respect to leisure-time physical activity and accompanying injuries. The study population experienced a relatively high number of injuries with clear differences in the injury risk between various activities so that the risk was highest in sports such as squash, orienteering, and contact and team sports. However, a high absolute number of injuries occurred in low-risk activities, such as gardening, walking, home-repair, and cycling, due to their frequent participation.

According to previous studies, the overall gender difference in the injury risk within a particular sport is small, but the differences by age groups are clear [1,8,14,18]. Injuries in adolescence are more frequent than those in adulthood. Concerning recreational and competitive sports the present study supports these findings, but, on the other hand, indicates that in commuting and lifestyle activities this trend is not so clear.

No previous study has compared the injury risks through a variety of leisure-time physical activity exposures. However, there are reports on injury risks in different sports. A Danish study showed that the highest overall injury rate (per 1000 playing and training hours) was in handball (8.3), followed by ice hockey (4.7), soccer (4.1), volleyball (3.1), badminton (2.9), and tennis (2.8) [11]. These figures are similar to those observed in the present study when accounting the time loss injuries only (52% of all injuries in recreational and competitive sports caused

Table **2** Participation of the cohort population (n = 3055) to various physical activities and the resulting injuries by activity

Activity	*Respondents reporting the activity*		*Number of injuries during the activity*	*Injuries per 1000 person-years of the*		*Number of injuries per 1000 hours of participation*	
	N	*%*		*entire cohort*	*active cohort*		*95% CI*
Commuting activity							
Cycling	1559	51	33	10.8	21.2	0.48	(0.34–0.68)
Walking	2669	87	62	20.3	23.2	0.19	(0.15–0.25)
Lifestyle activity							
Gardening	2532	83	233	76.2	92.0	1.01	(0.89–1.15)
Home repair	1740	57	136	44.5	78.2	0.54	(0.46–0.64)
Hunting, fishing orpicking berries	1653	54	34	11.1	20.6	0.33	(0.24–0.47)
Recreational and competitive sports							
Squash	27	0.9	17	5.6	629.6	18.3	(11.4–29.4)
Judo	11	0	15	4.9	1363.6	16.3	(9.8–27.0)
Orienteering	20	1	5	1.6	250.0	13.6	(5.6–32.6)
Rinkball	41	1	22	7.2	536.6	11.5	(7.6–17.5)
Floorball	249	8.1	139	45.5	558.2	10.9	(9.3–12.9)
Wrestling	8	0	5	1.6	625.0	9.1	(3.8–21.8)
Basketball	59	2	30	9.8	508.5	9.1	(6.3–12.9)
Soccer	191	6	85	27.8	445.0	7.8	(6.3–9.7)
Ice hockey	82	3	55	18.0	670.7	7.5	(5.8–9.8)
Volleyball	123	4	55	18.0	447.2	7.0	(5.4–9.1)
Karate	18	0.6	11	3.6	611.1	6.7	(3.7–12.1)
Finnish baseball	58	2	20	6.5	344.8	6.6	(4.3–10.3)
In-line skating	262	8.6	50	16.4	190.8	5.0	(3.9–6.6)
Tennis	85	2.8	16	5.2	188.2	4.7	(2.9–7.7)
Badminton	180	5.9	25	8.2	138.9	4.6	(3.1–6.8)
Motor sports	35	1,1	9	2.9	257.1	4.5	(2.3–8.6)
Downhill skiing	187	6.1	36	11.8	192.5	4.1	(3.0–5.7)
Track and field sports	22	0.7	7	2.3	318.2	3.8	(1.8–8.0)
Horse riding	64	2.1	35	11.4	546.9	3.7	(2.6–5.1)
Running	747	24.4	92	30.1	123.2	3.6	(2.9–4.4)
Skating	115	3.8	9	2.9	78.3	3.3	(1.7–6.4)
Aerobics, gymnastics	622	20.3	75	24.5	120.6	3.1	(2.5–3.9)
Gym training	514	16.8	96	31.4	186.8	3.1	(2.5–3.8)
Cycling	1570	51.3	98	32.0	62.4	2.0	(1.7–2.5)
Pole walking	346	11.3	19	6.2	54.9	1.7	(1.1–2.7)
X-country skiing	759	24.8	51	16.7	67.2	1.7	(1.3–2.2)
Rowing	77	2.5	4	1.3	51.9	1.5	(0.6–3.9)
Walking	2431	79.5	218	71.3	89.7	1.2	(1.0–1.3)
Swimming	1103	36.1	26	8.5	23.6	1.0	(0.65–1.40)
Dancing	1790	58.5	42	13.7	23.5	0.7	(0.55–1.01)
Golf	57	1.9	2	0.7	35.1	0.3	(0.07–1.12)

time loss). De Loës and Goldie reported injury risks (time loss injuries) in different sports and reported the highest risks in ice hockey, handball, and soccer. The lowest rates were found in individual sports such as swimming, skiing and gymnastics [4]. These findings are also in good accordance with those of present study.

To our knowledge, there are no previous comparative reports on safety of commuting and lifestyle activities. The present study gives good evidence that they include a low risk of injury. However, it seems that when commuting to shop, office or school it is safer to walk rather than ride a bike. If one makes comparison of injury risks between lifestyle activities and recreational and competitive sports it can be seen from the present results that gardening includes a similar risk to an injury as swimming. Hunting, fishing and picking berries include, in turn, similar risk of injury as playing golf.

Athletes usually spend far more time in training than competing. However, as about half of the acute injuries of the team-game athletes occur in competitions [14], it is evident that competitions involve a higher injury risk per hour of activity than training [16,26]. For example, in the recent prospective cohort study among registered floorball players, the injury rate per 1000

Table **3** Number of subjects, exposure hours and absolute number and age-specific incidence (per 1000 hours of participation) of leisure-time injuries in men and women

	Age group						*Total*	*p-values*	
	15–24	*25–34*	*35–44*	*45–54*	*55–64*	*65–74*		*Age*	*Sex*
Commuting activities								0.065	0.003
Men									
Cohort size	278	192	271	259	173	119	1292		
Exposure hours	31161	20577	26557	36885	20210	14232	149622		
Number of injuries	2	5	2	12	1	1	23		
Incidence*	0.1	0.2	0.1	0.3	0.1	0.1	0.2		
Women									
Cohort size	295	217	300	306	202	175	1495		
Exposure hours	56406	35931	43749	54989	28379	18051	237505		
Number of injuries	21	14	10	12	14	1	72		
Incidence*	0.4	0.4	0.2	0.2	0.5	0.1	0.3		
Lifestyle activities								0.24	< 0.001
Men									
Cohort size	267	197	297	291	196	131	1379		
Exposure hours	40042	47350	84610	84129	74854	48903	379888		
Number of injuries	19	26	54	60	40	26	225		
Incidence*	0.5	0.6	0.6	0.7	0.5	0.5	0.6		
Women									
Cohort size	238	206	286	308	217	157	1412		
Exposure hours	13767	24414	44487	49060	42401	29264	203393		
Number of injuries	14	32	51	26	35	20	178		
Incidence*	1.0	1.3	1.2	0.5	0.8	0.7	0.9		
Recreational and competitive sports								< 0.001	< 0.001
Men									
Cohort size	287	205	299	289	200	139	1419		
Exposure hours	75486	37103	53509	41859	36770	20563	265290		
Number of injuries	314	151	168	81	28	20	762		
Incidence*	4.2	4.1	3.1	1.9	0.8	1.0	2.9		
Women									
Cohort size	294	227	307	321	224	180	1553		
Exposure hours	64372	42049	48092	56391	39221	29685	279810		
Number of injuries	200	126	119	82	44	35	606		
Incidence*	3.1	3.0	2.5	1.5	1.1	1.2	2.2		

*Injury incidence per 1000 hours of participation.

game hours was 23.7 for men and 15.9 for women, while the injury rate per 1000 practice hours was no more than 1.0 for both sexes [26]. In the present study, intensity of each specific activity could not be specified and thus competitive and training hours were combined and analysed together.

Time lost from sports or work participation is often used as the criterion of injury occurrence and severity [6]. This "time loss" definition seems to be one of the standard ways of recording injuries although it is not always well associated with the severity and medical consequences of the injury. Clearly more complete coverage of injuries is obtained if the "no time loss" injuries are also recorded, for example, according to the method of Requa and Garrick [24]. Using this more sensitive injury definition, injuries with potentially serious sequelae that would not result in time loss (e.g. laceration or mild concussion) will also become reported. This "no time loss" definition of injury also better allows comparisons between various physical activities (commuting and lifestyle activities, and recreational and competitive sports), because athletes are often eager to return to their sports activities sooner (more frequent training schedules, return to activity even when insufficiently healed) than their noncompetitive counterparts. In the present study, both the "time loss" and "no time loss" injuries were recorded.

The present study has limitations which should be considered. First, a prospective interview-based approach that follows a large group of participants through a variety of exposures usually allows good comparison between various activities, but, on the other hand, may include more inaccuracies on case ascertainment and classification of injuries than a study which is based, for example, on patient files. In addition, the total injury incidence rate may become slightly underestimated, since not all first level injuries (complaints) may be reported. However, this should be the case in each activity, and so that comparison between different activities should be reliable. Second, a more

Table **4** Number of subjects, exposure hours and absolute number and age-specific incidence (per 1000 hours of participation) of injuries in the three main groups of recreational and competitive sports in men and women.

	Age group						Total	p-values	
	15–24	*25–34*	*35–44*	*45–54*	*55–64*	*65–74*		*Age*	*Sex*
Endurance sports								< 0.001	0.018
Men									
Cohort size	285	201	294	280	199	135	1394		
Exposure hours	34126	21325	37523	33001	33732	19198	178905		
Number of injuries	56	40	66	51	24	16	253		
Incidence*	1.6	1.9	1.8	1.5	0.7	0.8	1.4		
Women									
Cohort size	293	227	306	320	221	178	1545		
Exposure hours	48834	32950	40538	47574	34865	26968	231729		
Number of injuries	106	77	88	58	36	31	396		
Incidence*	2.2	2.3	2.2	1.2	1.0	1.1	1.7		
Team sports and ball games								< 0.001	0.69
Men									
Cohort size	188	87	114	63	16	9	477		
Exposure hours	25747	8118	10414	5115	1570	803	51767		
Number of injuries	196	76	82	22	1	4	381		
Incidence*	7.6	9.4	7.9	4.3	0.6	5.0	7.4		
Women									
Cohort size	79	44	43	27	9	3	205		
Exposure hours	5431	2217	1904	1862	634	67	12115		
Number of injuries	51	16	14	3	1	0	85		
Incidence*	9.4	7.2	7.4	1.6	1.6	0.0	7.0		
Power and contact sports								0.001	0.71
Men									
Cohort size	138	79	80	60	37	19	413		
Exposure hours	15431	6983	4880	3458	1469	562	32783		
Number of injuries	60	32	17	8	3	0	120		
Incidence*	3.9	4.6	3.5	2.3	2.0	0.0	3.7		
Women									
Cohort size	156	122	134	131	89	72	704		
Exposure hours	10088	6877	5649	6895	3642	2650	35801		
Number of injuries	43	34	17	20	8	3	125		
Incidence*	4.3	4.9	3.0	2.9	2.2	1.1	3.5		

* Injury incidence per 1000 hours of participation.

frequent interview protocol than used might have improved the coverage and accuracy of the data collection, but, on the other hand, it was assumed it would increase the noncompliance (dropout rate) of the study subjects and the risk for overlapping in injury reporting (same injury reported more than once).

The study also has strong points. First, the initial participation rate of the randomly recruited 15- to 74-year-old cohort population was high with a low number of dropouts during the follow-up. Second, we used an uniform definition of the injury and its severity in different physical activities, thus allowing comparison across various activities and sports. Third, the method of collecting the injury and exposure data was similar for the entire study population allowing reliable comparison of the individual risks of injury in different forms of activity.

Previous sports-specific epidemiological studies give evidence for the good reliability of the methods used in the present study. In the above noted one-year follow-up study among 295 competitive floorball players, the overall injury rate per 1000 playing hours was 9.5 [26]. In the present study, this rate was 10.9. Concerning a low-intensity activity (walking on a golf course), a recent prospective 20-week follow-up study showed that golfers sustained 0.33 injuries per 1000 playing hours [21]. In the present study, the finding was similar, 0.28 injuries per 1000 playing hours.

Controlled studies have indicated that it is possible to prevent sports-related injuries and that many of the interventions concerning large groups of participants which were effective enough to measurably alter injury profiles included changes in rules or improvements in equipment [20]. Based on existing knowledge on the injury profiles and mechanisms we should be able to teach recreational and competitive athletes what are the typical sports-specific injuries and their risks. To get this information from all new events of sports and from many low-to-moderate

Table **5** Distribution of the injuries according to the severity of the injury*

Activity	*Level I*		*Level II*		*Level III*	
	N	*%*	*N*	*%*	*N*	*%*
Commuting activity						
Cycling	21	45	17	36	9	19
Walking	28	41	23	34	17	25
Total	49	43	40	35	26	23
Lifestyle activity						
Gardening	112	54	66	32	30	14
Home repair	83	64	32	25	15	12
Hunting, fishing or picking berries	12	40	14	47	4	13
Total	207	56	112	30	49	13
Recreational and competitive sports						
Squash	12	71	4	24	1	6
Judo	12	60	7	35	1	5
Orienteering	7	70	3	30	0	0
Rinkball	9	41	10	45	3	14
Floorball	75	51	65	45	6	4
Wrestling	3	38	2	25	3	38
Basketball	14	41	18	53	2	6
Soccer	38	42	44	49	8	9
Ice hockey	35	58	13	22	12	20
Volleyball	17	31	25	46	12	22
Karate	6	60	4	40	0	0
Finnish baseball	7	37	9	47	3	16
In-line skating	37	66	15	27	4	7
Tennis	7	50	6	43	1	7
Badminton	10	40	14	56	1	4
Motor sports	7	54	6	46	0	0
Downhill skiing	25	58	15	35	3	7
Track and field sports	6	50	3	25	3	25
Horse riding	19	50	14	37	5	13
Running	33	35	56	59	6	6
Skating	5	50	4	40	1	10
Aerobics, gymnastics	39	50	35	45	4	5
Gym training	42	41	50	49	11	11
Cycling	69	62	29	26	14	13
Pole walking	10	56	6	33	2	11
X-country skiing	29	55	20	38	4	8
Rowing	3	50	3	50	0	0
Walking	79	38	100	49	27	13
Swimming	16	59	9	33	2	7
Dancing	24	60	13	33	3	8
Golf	0	0	2	100	0	0
Total	695	48	604	42	142	10

* For definition of each injury level, see Table **1**.

intensity noncompetitive activities, we will also need specific injury-monitoring, and, in addition to the group-level preventive strategies, we will have a continuous challenge to identify the injury-prone individuals, advise them on their leisure-time activities, and tailor their postinjury rehabilitation programs so that injury risk is minimised. Co-operation between investigators, physicians, sports organizations, and policy makers will be of great importance to increase safety in commuting and lifestyle activities, and recreational and competitive sports [20,23].

In conclusion, this prospective follow-up of a population cohort showed that individual injury risk per exposure hour is relatively low in commuting walking and cycling and many lifestyle activities, such as gardening, home repair, hunting and fishing, compared to many recreational and competitive sports. However, these low intensity activities are rather commonly practised and thus produce a relatively high absolute number of injuries, and therefore, preventive efforts are needed in these activities, too.

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