

Sport injuries in adolescents

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Abstract

In spite of the wide range of injuries in adolescents during sports activities, there are only a few studies investigating the type and frequency of sport injuries in puberty. However, this information may help to prevent, diagnose and treat sports injuries among teens. 4468 injuries in adolescent patients were treated over a ten year period of time: 66,97% were boys and 32,88% girls. The most frequent sports injuries were football (31.13%) followed by handball (8.89%) and sports during school (8.77%). The lower extremity was involved in 68.71% of the cases. Knee problems were seen in 29.79% of the patients; 2.57% spine and 1.99% head injuries. Injuries consisted primarily of distortions (35.34%) and ligament tears (18.76%); 9,00% of all injuries were fractures. We found more skin wounds (6:1) and fractures (7:2) in male patients compared to females. The risk of ligament tears was highest during skiing. Three of four ski injuries led to knee problems. Spine injuries were observed most often during horse riding (1:6). Head injuries were seen in bicycle accidents (1:3). Head injuries were seen in male patients much more often than in female patients (21:1). Fractures were noted during football (1:9), skiing (1:9), inline (2:3), and during school sports (1:11). Many adolescents participate in various sports. Notwithstanding the methodological problems with epidemiological data, there is no doubt about the large number of athletes sustain musculoskeletal injuries, sometimes serious. In most instances, the accident does not happened during professional sports and training. Therefore, school teachers and low league trainer play an important role preventing further accident based on knowledge of individual risk patterns of different sports.

It is imperative to provide preventive medical check-ups, to monitor the sport-specific needs for each individual sports, to observe the training skills as well as physical fitness needed and to evaluation coaches education.

Introduction

When we think of sports, we usually think about professional sports. We think about football, skiing or athletic competitions being performed by adults. Most sports are performed, however, by children and adolescents.¹ In the United States over 25-30 million children and adolescents take part in school sports activities and 20 million are members of sport clubs.^{2,3} The number of young athletes is continually increasing.^{1,4} Parallel to this increase of participants, the number of acute and over use injuries is raising.^{5,6}

Children and adolescents are at a special risk for injuries because most sports are not adapted to the motor skills of their specific age group.^{6,7} Thus, adolescents play according to the rules of adults and the apparatuses are not adjusted to their sizes.^{6,7} For example, the basketball baskets are just available in one height and almost all sports have only one ball size, the one used for adults.⁶ However, particularly adolescents may sustain injuries, which can impair their growth with potential lifelong effect.⁸

The aim of the following study was to provide epidemiologic data, which can aid to prevent, diagnose and treat sports injuries among adolescents.

Materials and Methods

Over a ten year period of time, all patients with sports injuries treated in the sports clinic were documented in a specially designed computer program. Since the implementation of the computerized case history, 17,397 patients with 19,530 injuries have been analyzed: 4468 injuries (25.68%) were related to patients between 10 and 19 years of age; 66,97% of the patients were male, 32,88% were female and the remaining 0.16% were of ambiguous gender (Table 1).

Patient's sex, kind of injury, localisation of injury and type of sports, as well as the treatment were documented. All patient examinations during outpatient clinic were performed either by, or under the supervision of, a senior consultant.

All patients were examined clinically regarding pain, swelling, range of motion, and stability. The clinical examination was followed by a radiographic evaluation (anterior-posterior and lateral view) depending on the type of injury. If the clinical and radio logic findings remained doubtful or required further investigation, the patients were transferred for ultrasound or MRI examination.

Sports injuries occurring during warm-up were not included in the study.

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Key words: epidemiology, sport injury, adolescent.

Received for publication: 13 September 2011.

Accepted for publication: 16 October 2011.

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Orthopedic Reviews 2011; 3:e18

doi:10.4081/or.2011.e18

Results

Sports

Most injuries occurred while engaging one popular European sports, soccer. Soccer was involved in 31.13% of all injuries followed by handball (8.89%), sports during school (8.77%), skiing (5.95%), and biking (5.71%) (Table 2).

Location

The upper extremities were involved in 25.27% of the injuries, the lower extremities in 68.71%, the spine in 2.57% and the head in 1.99% of the cases. Injuries of the upper extremity were seen on all locations with an especially high number of injuries at fingers (8.12%), metacarpus (3.13%) and wrist (3.54%). The knee (29.79%) and ankle joint (24.02%) were most often involved during injuries of the lower leg. Compared to knee and ankle joint, the shoulder (5.42%) and elbow (2.84%) were not often injured (Table 3).

Type of injury

Over all, injuries consisted primarily of distortions (35.34%) as well as ligament tears (18.76%); 9,00% of all injuries were fractures. (Table 3)

Gender

More than half of the male patients played ball games such as soccer (1311 patients), handball (222 patients) and basketball (168 patients). Girls skied (156 patients), danced (79 patients), and did gymnastic (123 patients). However, 175 girls played handball or had their accident during school sports (167 patients).

Type of injury

Looking at the over all distribution of boys and girls (2:1) we found more skin wounds (6:1) and fractures (7:2) in male patients. Girls showed more ligament tears (3:2).

Table 1. Gender specific location within 4468 sports injuries.

	No specification	Male	Female	Total
Head	0	85	4	89
Chest	0	16	3	19
Pelvis	0	38	8	46
Spine	0	65	50	115
Shoulder	2	199	53	254
Upper arm	0	14	5	19
Elbow	0	72	55	127
Forearm	0	51	17	68
Wrist	1	114	43	158
Hand	0	110	30	140
Finger	0	224	139	363
Hip	0	16	2	18
Thigh	0	130	58	188
Knee	1	773	557	1331
Lower leg	1	149	35	185
Ankle	1	756	316	1073
Foot	1	123	72	196
Toes	0	57	22	79
Total	7	2992	1469	4468

Sex and location

Compared to the overall distribution of male and female patients (2:1) head injuries were seen more often in male patients than in female patients (21:1). Shoulder, hand and lower leg injuries showed a boy-girl distribution of 4:1. We found a boy-girl distribution of 5:4 of spine, elbow and knee problems (Table 1).

Sports and location

In contrast to the overall relative number of head injuries (1:50), head injuries during bicycle accidents were seen much more often (1:10); 1:3 head injuries have been bicycling injuries. Spine injuries were observed in general with a distribution of 1:40. During horse riding 1 of 3 injuries affected the spine and 1:6 of all spine injuries were related to horse riding. Shoulder injuries were seen in 1:17 cases, shoulder injuries during skiing were seen with a distribution of 1:10. The overall hand and elbow injury rate was 1:30 and 1:35 respectively. During biking the hand (1:9) and elbow (1:8) were injured much more often. In general, finger injuries were seen in 1:12 patients. School sports primarily led to ankle sprains, nevertheless, every 5th accident during sports in school was located at the fingers. One third of all injuries were been related to the knee, 3:4 ski injuries led to knee problems (Table 4).

Sports and type of injury

The highest number ligament tears (279 patients) and joint sprains (500 patients) were

the results of accidents during soccer. The percentage of ligament tears compared to the overall number of accidents (1:5) was highest during skiing; 1:3 skiing injuries were ligamentous injuries. Approximately the same distribution was seen while playing handball (1:3). Fractures were noted among football (1:9), skiing (1:9), inline skating (2:3), and during school sports (1:11). The overall fracture rate was 1:11. Wrestling (1:5) and snowboarding (1:6) had a high number of dislocations compared to all dislocations that were seen (1:20). Wounds were seen most often after bike falls (1:5) (Table 2).

Location and type of injury

The injuries of the lower extremities consisted primarily of ligament tears: 1:5 injuries at the lower extremity were ligament tears and approximately all ligament tears occurred in the legs. Fractures were mostly seen at the upper extremity (Table 3).

Discussion

Little is known about sports-related injuries to the locomotor system in children and adolescents. However, these groups are the ones who are most likely to sustain injuries because they are constantly in motion. This is surely a sufficient motivation to gather epidemiological data to discuss the basics of their injuries.

Table 2. Sports specific diagnosis, sorted by number of injuries.

	Skin wound	Contusion	Distortion	Muscle injury	Ligament injury	Tendon injury	Dislocation Total	Fracture	Cartilage lesion	Total
Football	26	271	500	31	279	4	66	154	60	1391
Handball	16	53	168	2	83	14	15	22	24	397
Scholl Sport	0	88	188	12	52	1	11	36	4	392
Ski	6	16	96	0	86	1	22	30	9	266
Biking	75	85	28	0	24	0	7	18	18	255
Basketball	2	17	112	2	70	0	10	13	9	235
Gymnastics	1	34	49	4	25	1	6	17	29	166
Volleyball	0	16	75	3	40	0	12	3	6	155
Trek and Field	6	24	45	12	23	0	3	6	31	150
Tennis	9	9	38	3	20	0	5	6	38	128
Ice skating	3	24	27	5	11	1	7	10	9	97
Dance	0	14	38	7	12	0	7	4	8	90
Judo	2	23	21	6	8	0	9	5	5	79
Swimming	2	16	8	10	1	0	8	3	11	59
Jogging	0	2	27	6	13	1	1	2	3	55
Horse riding	0	29	5	0	4	0	1	8	2	49
Badminton	0	5	11	0	25	0	2	1	1	45
Wrestling	0	10	11	1	6	0	9	7	1	45
Inline skating	2	8	10	1	0	0	1	15	0	37
Skateboard	0	3	16	0	5	1	3	8	0	36

Adolescent are subjected to many stresses, strains and injuries. An increase in the number of injuries has been seen.^{1,4} In the United States alone, sports related injuries in children and adolescents cost more than 1.8 billion dollars per year.²

The actual incidence of injuries in children

and adolescents is difficult to determine. Between 3-11% of schoolchildren are injured each year.⁸⁻¹⁰ Children and adolescents may be particularly at risk for sports-related injuries as a result of improper technique, muscle weakness and poor proprioception.^{7,11,12}

Boys sustain twice as many injuries as girls.

In accordance with the literature two third of our patients were male.^{8-11,13} Males participating in sport may be at greater risk of injury as they tend to be more aggressive, have larger body mass, and experience greater contact compared with girls in the same sports and they more involved in contact sports and foot-

Table 3. Location specific diagnosis within 4468 sports injuries.

	Skin wound	Contusion	Distortion	Muscle injury	Ligament injury	Tendon injury	Dislocation Total	Fracture	Cartilage lesion	Total
Head	50	26	0	0	0	0	0	13	0	89
Chest	0	18	0	0	0	0	0	0	1	19
Pelvis	5	25	3	0	0	0	0	1	12	46
Spine	1	37	35	10	0	0	0	1	31	115
Shoulder	5	41	46	1	2	1	100	40	18	254
Upper arm	5	4	4	2	0	0	0	3	1	19
Elbow	15	52	20	0	7	0	11	8	14	127
Forearm	2	17	2	0	0	0	1	42	4	68
Wrist	2	38	87	1	0	0	1	23	6	158
Hand	7	39	29	0	2	0	1	56	6	140
Finger	6	89	156	0	22	15	11	64	0	363
Hip	6	7	1	0	0	2	0	0	2	18
Thigh	3	46	58	67	0	1	0	3	10	188
Knee	20	153	441	0	460	1	103	20	133	1331
Lower leg	19	53	0	39	1	4	0	55	14	185
Ankle	3	56	611	1	342	1	1	36	22	1073
Foot	12	80	58	0	2	0	0	23	21	196
Toes	1	32	28	0	0	0	1	14	3	79
Total	162	813	1579	121	838	25	230	402	298	4468

Table 4. Sports specific location, sorted by number of injuries.

	Head	Chest	Pelvis	Spine	Shoulder	Upper arm	Elbow	Fore arm	Wrist	Hand	Finger	Hip	Tight	Knee	Lower leg	Ankle	Foot	Toes	Total
Football	30	2	14	15	41	1	8	23	66	40	80	9	82	473	48	353	71	35	1391
Handball	11	0	1	0	23	6	7	0	3	28	57	0	4	117	1	126	11	2	397
Scholl Sport	6	5	3	6	17	1	9	1	8	4	77	1	10	78	18	134	13	1	392
Ski	0	0	0	0	29	1	0	1	2	1	16	0	8	196	10	2	0	0	266
Biking	27	4	6	1	16	0	33	8	28	23	6	5	3	47	25	6	17	0	255
Basketball	2	2	0	3	7	0	2	0	0	6	42	0	3	48	2	116	2	0	235
Gymnastics	1	1	1	18	10	1	12	8	15	3	9	0	9	34	9	25	9	1	166
Volleyball	1	0	0	3	9	0	4	0	3	3	28	0	1	21	1	76	5	0	155
Trek and Field	0	0	8	13	3	0	1	0	2	7	0	1	19	34	19	37	3	3	150
Tennis	0	0	2	9	9	2	1	1	9	0	3	0	0	34	9	35	8	6	128
Ice skating	2	1	6	2	6	0	2	1	3	7	16	0	3	34	3	7	3	1	97
Dance	0	0	0	0	2	0	1	0	0	1	1	2	10	21	2	29	19	2	90
Judo	2	0	0	1	9	0	12	0	1	0	3	0	7	21	0	2	11	10	79
Swimming	1	0	0	3	9	2	11	2	0	0	0	0	2	8	12	1	2	6	59
Jogging	0	0	0	0	1	0	0	0	0	0	1	0	1	13	7	25	2	5	55
Horse riding	0	0	0	19	1	0	0	0	0	0	0	0	6	13	1	4	4	1	49
Badminton	0	0	1	2	0	0	0	1	0	0	0	0	0	35	0	6	0	0	45
Wrestling	0	2	1	1	16	1	10	1	1	1	3	0	0	3	3	2	0	0	45
Inline skating	1	0	1	0	2	0	2	5	5	5	3	0	1	5	1	6	0	0	37
Skateboard	0	0	0	5	3	0	0	0	4	1	5	0	0	3	1	14	0	0	36
Total	1	0	1	0	2	0	2	5	5	5	3	0	1	5	1	6	0	0	37

ball.^{11,13} All of these factors may lead to increased forces in running, jumping, pivoting, and contact, which may increase susceptibility to injury.¹¹ Underlining this, we found more skin wounds and fractures as well as head and shoulder injuries in males.

Therefore, paediatric orthopaedic patients fall into two groups: *obese* patients or young athletes.¹⁴ On one hand, due to our technological environment, adolescents tend not to be as active anymore and through this do not have the level of coordination that one would suspect.^{6,14} On the other hand, youths tend to have reduced perception of risk and boundless energy.¹⁵ In addition, the sports apparatuses are rarely tailored to the needs of the adolescent.^{7,16} Skiing is one of the only sports where the height and weight of each individual is taken into consideration when giving out equipment. Adolescents play according to the rules of adults and the apparatuses are not adjusted to their sizes.⁷

However, most sports are not adapted to the motor skills and size of adolescents.^{6,7} Adolescents play according to the rules of adults.^{6,7} Almost all sports have only one ball size, the one used for adults.⁶ However, particularly adolescents may benefit from sports equipment adapted to their needs.⁸

Teachers deal with all kind of problems, because the school population is not specially selected or trained. Therefore they have to simultaneously handle obese patients, young athletes, low level of coordination, and reduced perception of risk, as well as adult sports equipment.¹⁷ Playing with adult-sized balls, sports injuries account for a significant morbidity with frequent finger injuries among adolescents during sports in school. 8.77% of all injuries we have seen were caused during school sports. School sports primarily led to ankle sprains and every 5th accident was located at the fingers; 9% of those injuries were fractures.

The province of Quebec does not allow adolescents to body check until the age of 14, whereas in Ontario they are already allowed to at the age of 10 to 12 years. Analysis of hockey injuries in the two provinces showed a higher incidence of injury when checks were allowed, with a higher proportion of head injuries and fractures. A simple change in regulation could prevent many injuries among adolescents playing hockey.¹⁸

The Toronto District School Board abruptly removed playground equipment from 136 schools because it was dangerously non-compliant with standards. After the equipment was removed and replaced with safe equipment, the injury rates dropped down by 50%. The same number of children did the same playing, but in a safe environment. Therefore the injury risk was substantially reduced.¹⁹

The examples of playground and ice hockey

are not exhaustive for formal and organized sports and leisure activities. We found a high number of head injuries during bicycle accidents and spine injuries were observed during horse riding. These injuries might be reduced by wearing a helmet or and spinal protection even during leisure bike rides or horse riding.

Elevated speed and falls from greater heights are the cause of severe injuries.¹⁰ The most dangerous sports are today's most popular sports such as snowboarding, carving and inline skating.²⁰⁻²² In his study Diamond found that skiing poses an especially high risk for head injuries in children.²³ Accidents are due to balance problems and collisions.²⁰ Beginners have more injuries of the forearm (46%) and the most advanced tend to suffer from head and neck injuries (30%).²² A situation possible to be changed by better protection of the head. Out of our personal experience coaches appear to have a specific perception concerning the causes of sports accidents. They somehow believe that factors like methods or organization of the game do not have an effect on accidents.⁷ In addition, adolescents are under intense pressure, with a higher level of training, to meet the expectation from the coach and their parents.³

On the other hand there are exogenous factors such as apparatuses, which are not adapted to the adolescents' size, as well as endogenous factors such as the individual level of performance that are important for the cause of injuries. Potential factors adapted from Emery were listed in Table 5.¹¹

Beside the above mentioned, the type of sport is a deciding factor and determines the rate of injury as well as the localisation and the resulting diagnosis.^{13,22,24} In our study ball games like soccer, handball and basketball in boys and school sports, handball and skiing in girls accounted for the highest number of injuries. An American study showed that injury occurred most often during basketball, soccer, baseball, football and roller blading.¹³ 62% of sports injuries take place in athletic clubs, 21%

in school sports, and 17% during leisure sports. Abernethy reported an even higher percent of schools sports injuries with 51%.^{25,26}

It is quite noticeable that adolescents have the same types of injuries that adults have.^{13,27} Patel stated in his work on sport injuries in adolescents, that most common types of injuries are soft tissue injuries as sprains, strains, and contusions.²⁸ However, in our study 9% of all injuries had been fractures.

Our unique description of epidemiological data of adolescents sport injuries, showed the highest number ligament tears and joint sprains as a result of accidents during soccer. Never less, the risk of ligament injury was highest during skiing and handball. Fractures were noted among soccer, skiing, inline skating, and during school sports and dislocations were seen during wrestling. Injuries of the lower extremities consisted primarily of ligament tears and fractures were mostly seen at the upper extremity.

In conclusion school teachers and coaches play an important role preventing further accidents based on knowledge of individual risk patterns of individual sports. Risk factors may be extrinsic (sport, position, level, weather) or intrinsic (previous injury, sex) to the individual participating in sports. Modifiable risk factors refer to those with the potential to be altered by injury prevention strategies such as education or behavioural intervention (rules, playing time), environmental interventions (playing surface, equipment), and legislative interventions.¹¹

However, a reduction of the incidence of injuries should not only be confined to a modification of rules and apparatuses. It is imperative to provide preventive medical check-ups, to monitor the sport-specific needs for each individual sports, to observe the training skills as well as physical fitness needed and to evaluate coaches education. This is an important duty for each paediatrician or family physician who is interested in sports medicine.

Table 5. Potential risk factors for injury in adolescent sport.

	Extrinsic risk factors	Intrinsic risk factors
Non-modifiable	Kind of sport Level of sport Position Time of season Weather	Age Previous injury Sex
Potential modifiable	Equipment Playing surface Playing time Rules Time of day	Coordination Fitness level Flexibility Participation in sport-specific training Proprioception Psychological factors Strength

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