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 injuries during 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 then 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 accidents 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 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. 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. The number of young athletes is continually increasing. Parallel to this increase of participants, the number of acute and over use injuries is raising.

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. Thus, adolescents play according to the rules of adults and the apparatuses are not adjusted to their sizes. 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. However, particularly adolescents may sustain injuries, which can impair their growth with potential lifelong effect.

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 in adolescent patients (21:1). Girls skied (156 patients), danced (79 patients) and did handball (60 patients). Fractures were noted during 19,530 injuries (25.68%) were related to patients with 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 (anterioposterior 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.

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 gymnastics (123 patients). However, 175 girls played handball or had their accident during school sports (167 patients).
Type of injury

Looking at the overall 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).

| Sport      | Skin wound | Contusion | Distortion | Muscle injury | Ligament injury | Tendon injury | Dislocation | 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    |

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 were 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 1:20. 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 1. Gender specific location within 4468 sports injuries.

| Location | 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  |

Table 2. Sports specific diagnosis, sorted by number of injuries.
Adolescent are subjected to many stresses, strains and injuries. An increase in the number of injuries has been seen. In the United States alone, sports related injuries in children and adolescents cost more than 1.8 billion dollars per year.

The actual incidence of injuries in children and adolescents is difficult to determine. Between 3-11% of schoolchildren are injured each year. Children and adolescents may be particularly at risk for sports-related injuries as a result of improper technique, muscle weakness and poor proprioception.

Boys sustain twice as many injuries as girls.

### Table 3. Location specific diagnosis within 4468 sports injuries.

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

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

| Sport            | Head | Chest | Pelvis | 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   |
| Handball         | 11   | 0     | 1      | 0        | 23        | 6     | 7        | 0     | 3    | 28     | 57 | 0      | 4    | 117       | 1    | 126  | 11   | 2    |
| Scholl Sport     | 6    | 5     | 3      | 6        | 17        | 1     | 9        | 1     | 8    | 4      | 77 | 1      | 10   | 78        | 18   | 134  | 13   | 1    |
| Ski              | 0    | 0     | 0      | 29       | 1         | 0     | 1        | 2     | 1    | 16     | 0  | 8      | 196  | 10        | 2    | 0    | 26   | 6    |
| Biking           | 27   | 4     | 6      | 1        | 16        | 0     | 33       | 8     | 28   | 23     | 6  | 5      | 3    | 47        | 25   | 6    | 17   | 2    |
| Basketball       | 2    | 2     | 0      | 3        | 17        | 0     | 2        | 0     | 0    | 6      | 42 | 0      | 3    | 48        | 2    | 116  | 2    | 0    |
| Gymnastics       | 1    | 1     | 1      | 14       | 10        | 1     | 12       | 8     | 15   | 3      | 9  | 0      | 9    | 34        | 9    | 25   | 9    | 1    |
| Volleyball       | 1    | 0     | 0      | 3        | 9         | 0     | 4        | 0     | 3    | 3      | 28 | 0      | 1    | 21        | 1    | 76   | 5    | 0    |
| Trek and Field   | 0    | 0     | 0      | 8        | 13        | 3     | 0        | 1     | 2    | 7      | 0  | 1      | 19   | 34        | 19   | 37   | 3    | 3    |
| Tennis           | 0    | 0     | 2      | 9        | 9         | 2     | 1        | 1     | 9    | 0      | 3  | 0      | 0    | 34        | 9    | 35   | 8    | 128  |
| Ice skating      | 2    | 1     | 6      | 2        | 6         | 0     | 2        | 1     | 3    | 7      | 16 | 0      | 3    | 34        | 3    | 7    | 3    | 1    |
| Dance            | 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   | 79   |
| Swimming         | 1    | 0     | 0      | 3        | 9         | 2     | 11       | 2     | 11   | 0      | 0 | 0      | 2    | 8        | 12   | 1    | 2    | 58   |
| Jogging          | 0    | 0     | 0      | 0        | 0         | 1     | 0        | 0     | 0    | 0      | 0 | 1      | 0    | 13        | 7    | 25   | 2    | 55   |
| Horse riding     | 0    | 0     | 0      | 19       | 1         | 0     | 0        | 0     | 0    | 0      | 0 | 6      | 13   | 1        | 4    | 4    | 1    | 49   |
| Badminton        | 0    | 0     | 1      | 2        | 0         | 0     | 0        | 0     | 0    | 0      | 0 | 0      | 35   | 0        | 6    | 0    | 45   |
| Wrestling        | 0    | 2     | 1      | 16       | 1          | 10    | 1        | 1     | 1    | 1      | 3  | 0      | 0    | 3        | 3    | 3    | 2    | 0    |
| Inline skating   | 1    | 0     | 0      | 2        | 0         | 2     | 5        | 5     | 5    | 3      | 0 | 1      | 5    | 1        | 6    | 0    | 37   |
| Skateboard       | 0    | 0     | 0      | 5        | 3         | 0     | 0        | 0     | 4    | 1      | 5 | 0      | 0    | 3        | 1    | 14   | 0    | 36   |
| Total            | 1    | 0     | 1      | 0        | 2         | 0     | 2        | 5     | 5    | 5      | 3 | 0      | 1    | 5        | 5    | 6    | 0    | 37   |
ball.\textsuperscript{11,13} All of these factors may lead to increased forces in running, jumping, pivoting, and contact, which may increase susceptibility to injury.\textsuperscript{13} 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.\textsuperscript{14} On one hand, due to our technical environment, adolescents tend not to be as active anymore and through this do not have the level of coordination that one would suspect.\textsuperscript{6,14} On the other hand, youths tend to have reduced perception of risk and boundless energy.\textsuperscript{15} In addition, the sports apparatuses are rarely tailored to the needs of the adolescent.\textsuperscript{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.\textsuperscript{7}

However, most sports are not adapted to the motor skills and size of adolescents.\textsuperscript{6,7} Adolescents play according to the rules of adults.\textsuperscript{6,7} Almost all sports have only one ball size, the one used for adults.\textsuperscript{4} However, particularly adolescents may benefit from sports equipment adapted to their needs.\textsuperscript{8}

Teachers deal with all kinds 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{10} The most dangerous sports are today’s most popular sports such as snowboarding, carving and inline skating.\textsuperscript{20,22} In his study Diamond found that skiing poses an especially high risk for head injuries in children.\textsuperscript{21} Accidents are due to balance problems and collisions.\textsuperscript{20} Beginners have more injuries of the forearm (46%) and the most advanced tend to suffer from head and neck injuries (30%).\textsuperscript{22} A situation possible to change 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.\textsuperscript{7} In addition, adolescents are under intense pressure, with a higher level of training, to meet the expectation from the coach and their parents.\textsuperscript{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.\textsuperscript{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.\textsuperscript{3,12,24} 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.\textsuperscript{12,23} 21% 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%.\textsuperscript{5,26}

It is quite noticeable that adolescents have the same types of injuries that adults have.\textsuperscript{3,27} 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.\textsuperscript{20} 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.\textsuperscript{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         | Age                    |
| Kind of sport          | Previous injury        |
| Level of sport         | Sex                    |
| Position               |                        |
| Time of season         |                        |
| Weather                |                        |
| Potential modifiable   | Coordination           |
| Equipment              | Fitness level           |
| Playing surface        | Flexibility             |
| Playing time           | Participation in sport-specific training |
| Rules                  | Psychological factors   |
| Time of day            | Strength                |
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