Published in final edited form as:
Phys Sportsmed. 2014 May ; 42(2): 146–153. doi:10.3810/psm.2014.05.2066.

Epidemiology of Basketball, Soccer, and Volleyball Injuries in Middle-School Female Athletes

Kim D. Barber Foss, MS, ATC[1,2], **Greg D. Myer, PhD**[1], and **Timothy E. Hewett, PhD**[1,3]

[1]Cincinnati Children's Hospital Medical Center, Cincinnati, OH; Sports Medicine Biodynamics Center and Human Performance Laboratory, Cincinnati, OH

[2]Division of Health Sciences, Department of Athletic Training, College of Mount St. Joseph, Cincinnati, OH

[3]Departments of Pediatrics, Biomedical Engineering, and Rehabilitation Sciences, University of Cincinnati, Cincinnati, OH; Departments of Orthopaedic Surgery, Physiology and Cell Biology, and Family Medicine, College of Medicine, University of Cincinnati, Cincinnati, OH; and Department of Biomedical Engineering and School of Rehab Sciences, Ohio State University, Columbus, OH

Abstract

Background—An estimated 30 to 40 million school children participate in sports in the United States; 34% of middle-school participants become injured and seek medical treatment at an annual cost close to $2 billion. The purpose of the current study was to evaluate the injury incidence and rates in female athletes in the middle-school setting during the course of 3 seasons.

Methods—Female basketball, soccer, and volleyball players were recruited from a single county public school district in Kentucky consisting of 5 middle schools. A total of 268 female athletes (162 basketball, 26 soccer, and 80 volleyball) participated. Athletes were monitored for sports-related injury and number of athlete exposures (AEs) by an athletic trainer. Injury rates were calculated for specific types of injuries within each sport. Injury rates for games and practices were also calculated and compared for each sport.

Results—A total of 134 injuries were recorded during the 3 sport seasons. The knee was the most commonly injured body part (99 injuries [73.9%]), of which patellofemoral dysfunction (31.3%), Osgood-Schlatter disease (10.4%), and Sinding-Larsen-Johansson/patella tendinosis (9%) had the greatest incidence. The ankle was the second most commonly injured body part, accounting for 16.4% of all injuries. The overall rates of injury by sport were as follows: soccer, 6.66 per 1000 AEs; volleyball, 3.68 per 1000 AEs; and basketball, 2.86 per 1000 AEs.

Correspondence: Kim Barber Foss, MS, ATC, Cincinnati Children's Hospital, 3333 Burnet Avenue, MLC 10001, Cincinnati, OH 45229. Tel: 513-636-5971, Fax: 513-636-6374, Kim.Foss@cchmc.org.

Conflict of Interest Statement

Kim D. Barber Foss, MS, ATC, Greg D. Myer, PhD, and Timothy E. Hewett, PhD, have no conflicts of interest to declare.

Conclusions—Female middle-school athletes displayed comparable injury patterns to those seen in their high-school counterparts. Future work is warranted to determine the potential for improved outcomes in female middle-school athletes with access to athletic training services.

Clinical Relevance—As the participation levels and number of injuries continue to rise, middle-school athletes demonstrate an increasing need for medical services provided by a certified athletic trainer.

Keywords

epidemiology; middle-school athletics; sports injuries; injury rates

Introduction

During the last decade there has been a 21% increase in the number of schoolchildren (aged 5–18 years) participating in sports in the United States, which is now estimated at between 30 and 40 million athletes.[1–3] These athletes sustain 4 million sports-related injuries annually and require approximately 2.6 million emergency room visits at a cost of nearly $2 billion.[1,3–6]

Middle-school athletes are not just younger versions of their high-school counterparts. Some students who are still skeletally immature may be more prone to growth-plate injuries when the epiphyseal physes are still open. These athletes may also be at increased risk of injury due to imbalances among neuromuscular control, strength, and flexibility.[7–9] During this period of rapid growth and open physes, the areas of growth cartilage are potentially more prone to injury than the articular cartilage of adults.[10] Between the ages of 6 to 14 years, the increase in limb mass is double the increase in limb length, which may create a force imbalance and decreased lower extremity control.[7,11–14] The increased susceptibility of injury of these younger athletes could also be due to their poorer balance, coordination, and flexibility, while muscles and tendons lag behind during this phase of rapid bone growth.[3]

Although participation in sports has many positive effects, such as improved body composition[15] and cardiorespiratory function[6,15] as well as increased psychosocial well-being, it also carries an increased risk of sports-related injury.[6,15–17] Female athletes have a 2- to 10-fold increased risk of certain injuries, such as anterior cruciate ligament sprains and development of patellofemoral pain in the collegiate and high-school settings.[18–21] Previous injury surveillance research in the high-school setting determined injury rates for female athletes in the sports of basketball, soccer, and volleyball to be 4.4, 5.3, and 1.7 per 1000 athlete exposures (AEs), respectively.[22] An AE (or opportunity for injury) is defined as 1 athlete participating in 1 coach-directed session (game or practice). A prior youth soccer epidemiology study that utilized parent recording of injuries and actual hours of playing time found a rate of 4.7 per 1000 AE hours for acute injury.[23] Although the descriptive injury epidemiology research conducted at the collegiate and high-school levels is well represented in the literature, there is a paucity of research for female athletes in the middle-school setting. Therefore, the purpose of our study was to prospectively monitor the incidence of injury among female middle-school athletes participating in the sports of basketball, soccer, and volleyball.

Methods

Female basketball, soccer, and volleyball athletes from a single county public school district in Kentucky consisting of 5 middle schools participated in this study. A total of 268 athletes (162 basketball, 26 soccer, and 80 volleyball) participated (100% recruitment of teams), and resulted in > 95% compliance with data monitoring. Soccer and volleyball are fall season sports and basketball is a winter sport in this study population. The subjects had the opportunity to participate in both the fall and winter sport seasons. Injuries were recorded in the specific season in which they occurred. The Cincinnati Children's Hospital Institutional Review Board approved the data collection procedures and consent forms. Parental consent and athlete assent were obtained before initiation of data collection.

Athletes were evaluated weekly for any sports-related injury by an athletic trainer (AT) during each sports season. The AT also met weekly with the coach to discuss the athletes who missed time from practice or competition as a result of an injury or pain. This cross-check system ensured that all athlete injuries or pains were captured by the AT. The definition of injury included those that caused cessation of participation in the current session and those that caused cessation of participation on the day after onset, such as fractures, dental injuries, and mild traumatic brain injuries, regardless of how much time was lost.[22,24] Athlete exposures were recorded by a coach on a weekly basis and verified by the study coordinator. Exposure data were entered by the coach into a sports injury surveillance system. Injuries were recorded by the AT in the Sports Injury Monitoring System (Flantech, Iowa City, IA).

Statistical Analyses

Data were analyzed for descriptive statistics and frequency counts for the types of reported injuries. Calculations were made to determine injury rates for each sport, and comparisons were made between game and practice rates. Statistical analyses were performed with SPSS software, version 17.0.

Results

A total of 134 injuries (Table 1) were recorded by the AT during 3 sports seasons (2009–2010), yielding a risk of injury of 50%. Almost twice as many injuries occurred in practice (n = 86) than in competition (n = 48), with injury rates of 3.1 and 3.4 per 1000 AEs in practice and games, respectively. The overall rates of injury by sport were as follows: soccer, 6.66 per 1000 AEs; volleyball, 3.68 per 1000 AEs; and basketball, 2.86 per 1000 AEs. The relative risk of injury in soccer was more than twice as high as that in basketball and 1.8 times as high as that in volleyball. Basketball yielded the most total reported injuries at 84 (62.7%), followed by volleyball with 38 (28.4%) and then soccer with 12 (8.9%).

In the sample of all 3 sports combined, the most frequently injured body part was the knee (73.9%), with the ankle/foot a distant second (17.2%; Table 2; Figure 1). The most frequent types of injury classification were pain/inflammation (53.0%), sprain/subluxation (25.4%), strain/tendinopathy (11.2%), and contusion (7.5%; Table 3). There were a total of 99 (73.9%) injuries to the knee, of which patellofemoral dysfunction (PFD; 31.3%), Osgood-

Schlatter disease (10.4%), and Sinding-Larsen-Johansson/patella tendinosis (9%) had the greatest incidence (Table 1). Knee injuries were 2.5 times more likely to occur during a practice session.

Soccer Injuries

There were 12 reported soccer-related injuries evenly split in occurrence between competition and practice, but the game rate was 9.05 per 1000 AEs and the practice rate was 5.27 per 1000 AEs. Similar to the results in basketball, the knee was the most commonly injured body part (91.7%), followed by the ankle (8.3%). The most common types of injury in middle school soccer were pain/inflammation (50%), strain/tendinopathy (25%), and sprain/subluxation (16.7%). The relative risk of injury was more than twice as high in soccer than in basketball (Table 4).

Basketball Injuries

There were a total of 84 basketball-related injuries, with 39 (46.4%) occurring in a competition setting and 45 (53.6%) occurring during practice. The overall rate of injury for basketball was 4.20 per 1000 AEs for games and 2.24 per 1000 AEs for practice. The most common body part injured was the knee (67.9%), followed by the ankle (21.4%) and the hand (3.6%). Of the 57 knee injuries, 35 (61.4%) occurred during games and 22 (38.6%) during practice. Ankle injuries were the opposite, with 72.2% occurring during competition and 27.8% during practice. The most common type of basketball-related injury classification was pain/inflammation (includes diagnoses of PFD, bursitis, plica, etc) at 45.2%. This was followed by sprain/subluxation (31%), contusion (9.5%), strain/tendinopathy (9.5%), and fracture (2.4%; Table 5).

Volleyball Injuries

The injury rate in volleyball was higher for practice (5.55 per 1000 AEs) than for games (0.75 per 1000 AEs), which is different from what was found for both basketball and soccer. Of the 38 reported injuries, 35 (92.1%) occurred during practice. Similar to basketball and soccer, the most common body part injured was the knee (81.6%), followed by the ankle (7.9%) and the shoulder (7.9%; Table 6). The most common types of injury in volleyball were pain/inflammation (71.1%), sprain/subluxation (15.8%), and strain/tendinopathy (10.5%).

Discussion

The purpose of this study was to prospectively monitor the incidence of injury among female middle-school athletes participating in the sports of basketball, soccer, and volleyball. There is limited sports epidemiology research on sports-related injury in the middle-school population, and what is available is mainly sourced as data aggregated from emergency department visits,[5] which may not give an accurate portrayal or representation of all sports injuries. Injury incidence data from this study population were compared with previous research on corresponding high-school athletes. Middle-school athletes demonstrated injury pattern characteristics that were similar to those of their high-school

counterparts, yet the overall injury rates and those for games and practices were higher in the middle-school setting.

Across all 3 sports we found that the knee and ankle were the 2 most injured body parts (91.1%), similar to previous research reported on 5- to 14-year-olds presenting to emergency departments.[15] The knee is the second most injured body part among high-school athletes.[6] However, the knee is the primary site of injury at the middle-school level based on the current data. The ankle is the most common body part injured in high-school athletics.[17] Ankle injury rates are reported to be higher in competition than in practice settings.[17] It is theorized that adolescents are more likely to suffer an ankle injury than a prepubescent athlete because of the development of greater body mass during maturation.[17] Ankle sprain was not the most common body part or injury in the middle-school athlete in this study population, but it was second to knee injury.

It is interesting to note that our data showed that knee injuries were 2.5 times more likely to occur in a practice session, whereas in older adolescent athletes knee injuries were 3 times more likely to occur in competition.[6] Lower extremity injuries were reported to occur in similar proportion between practice and competitions in high school, whereas our data show twice as many injuries occurred during practice versus competition.[25] This unique finding may be postulated to be due to the higher incidence of anterior knee pain in this population, a condition that often has an insidious onset that would more likely be attributed to occurring from practice.[26] In addition, prior studies have indicated that the neuromechanics of the knee are most disrupted during maturation, which may also increase the risk of injury in middle-school athlete. This finding and speculated theories warrant further investigation to glean more definitive mechanistic underpinnings.

Previous research has shown that the most common knee injuries were ligament tears, contusions, cartilage damage, fractures, and muscle tears, and less common were tendonitis and inflammation.[6] The current data, as displayed in Figure 2, showed a preponderance of injury related to pain and inflammation, with sprain, strain, and contusion injury classifications secondary. This unique difference in the current injury type data could likely be attributed to the significant incidence of anterior knee pain in this study population; 31% of all reported injuries in the current study were diagnosed as PFD, with an additional 28% of injuries (plica, pes anserine bursitis, etc) categorized as anterior knee pain. These findings support similar results in which all incidents of new prospective occurrences of PFD occurred in the middle-school athlete.[26]

In the United States, an estimated 15.5 million people participate in soccer. Two national youth organizations have registered 650 000 and 3.2 million participants aged younger than 19 years, with a 7% increase in female adolescent players from 2001 to 2007.[27] The growth in children's soccer is occurring at 11% to 22% annually.[28] Soccer is the leading source of reported sports-related injury in girls.[29] Nationally, an estimated 1.6 million soccer-related injuries present to the emergency department annually with a mean age of 13 years.[28] The current study found a game rate of 9.05 per 1000 AEs and 5.27 per 1000 AEs in practice, whereas a prior youth soccer epidemiology study found a rate of 4.7 per 1000 AE hours for acute injury.[23] Prior work has demonstrated that girls have higher rates of ankle and knee

injuries than their male counterparts, with a rate of lower extremity injuries for girls 1.59 per 1000 AEs.[7,27,29] The most common location of injury was the ankle, knee, and thigh,[28–30] and the most common types of injuries were sprains/strains, contusions, and fractures.[28–30] Girls sustain more ligament sprain injuries during competition.[30] Of the 12 soccer-related injuries reported, 11 were to the knee and 1 was to the ankle (Figure 3). Although the injuries overall were split equally between games and practices, given the higher number of practice exposures the injury rate for games was 9.05 per 1000 AEs versus the rate for practice was 5.27 per 1000 AEs. All sprain injuries occurred during competition. Although the current data are similar to what was previously reported in the high-school setting, our study sample size for soccer (n = 26) was small and should be interpreted with caution.

In pediatric volleyball participants, the most commonly injured body parts were previously reported to occur in the upper extremity, followed by the lower extremity.[31] Fingers were the most common upper extremity injury, and ankles were the most common lower extremity injury, with the most common type of injury being a sprain/strain.[31] Similar to basketball and volleyball, other researchers have found the most common injury among young volleyball players is an ankle sprain.[7] The current data for volleyball showed a similar trend; in the other 2 sports, knee injury was the most prevalent, followed by ankle and shoulder injuries (Figure 4). Pain/inflammation was the most common injury classification, followed by sprain/subluxation and strain/tendinopathy. Volleyball was the only sport that had a higher incidence of injury in practice sessions than in games.

Basketball continues to be the most popular team sport in the United States and remains the leading sport for sports-related injuries, causing 40% more injuries than football.[32,33] Previous research in the high-school setting has shown that in basketball, injuries most often occur to the extremities (hands, wrists, ankles, and knees), with ankle sprain being the most common type of injury and injury location.[34,35] The current findings support this, with the lower extremity being injured more frequently than the upper extremity; however, the knee was the most commonly injured body part, followed by the ankle (Figure 5).

Previous work on high-school injury epidemiology has found that sprains, strains, and lower extremity injuries accounted for the majority of sports-related injuries, regardless of sport or type of session.[25] Given our similar results in the middle-school setting, the risk of injury may not be entirely sport-specific, but it may be more attributable to these sports being composed of similar components of running, jumping, and cutting. One of the limitations of the current study was the small sample size for soccer. Although we tested all of the 6th through 8th grade teams in basketball and volleyball, soccer was not a school-sponsored sport at that level. As a result, only 1 of the middle schools offered a school-based soccer team; however, their competitions occurred through a community league.

Future research should examine additional soccer teams at this age level to see if the injury incidence trend evident in the present data held true and if the results are similar to the data presented by Schiff et al.[23] However, consideration of the similarity in the injury rates found at both the middle-school and high school setting, combined with the absence of sports injury coverage at most middle-school sporting events, indicates that further assessment of the need for AT coverage in the middle-school setting is warranted. Although within-sample

comparisons are optimal to evaluate direct sex differences in injury rates, the current investigation was limited to female athletes. Future studies aimed at determining sex differences in middle-school injury patterns would benefit from a more diverse and mixed sex sample to improve generalizability. A final consideration for this study is that the sample size for soccer was relatively small. Although we were diligent in the data collection and analyses, interpretation and generalization of these sport-specific data must be done cautiously. A multicenter study examining the same sports at the middle-school level would be an ideal progression from this current investigation.

Conclusion

Middle-school athletes display similar injury patterns to those of high-school athletes, but additional research should be conducted for this age level. As the participation levels and number of injuries continue to rise, middle-school athletes may develop an increasing need for medical services and coverage provided by a certified AT. Future research is warranted to determine the potential for improved outcomes in middle-school populations with access to AT services.

Acknowledgments

This work was supported by National Institutes of Health grants R01-AR049735, R01-AR055563, R01-AR056259, and R03-057551. The authors thank the Sports Medicine Biodynamics Center at Cincinnati Children's Hospital for its support. The authors thank the Boone County, Kentucky, school district for participating in this study.

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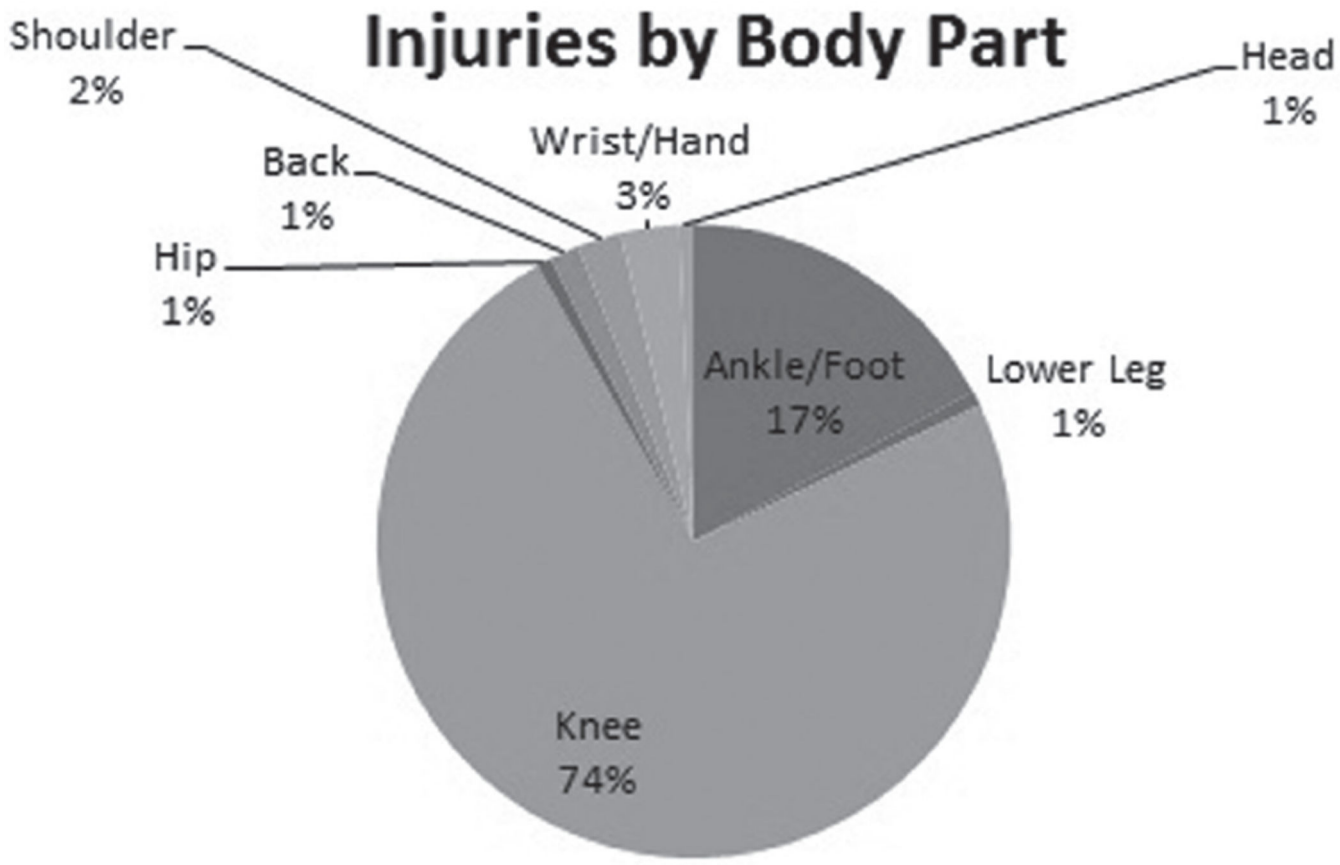

Figure 1.
Injuries by body part across all 3 sports.

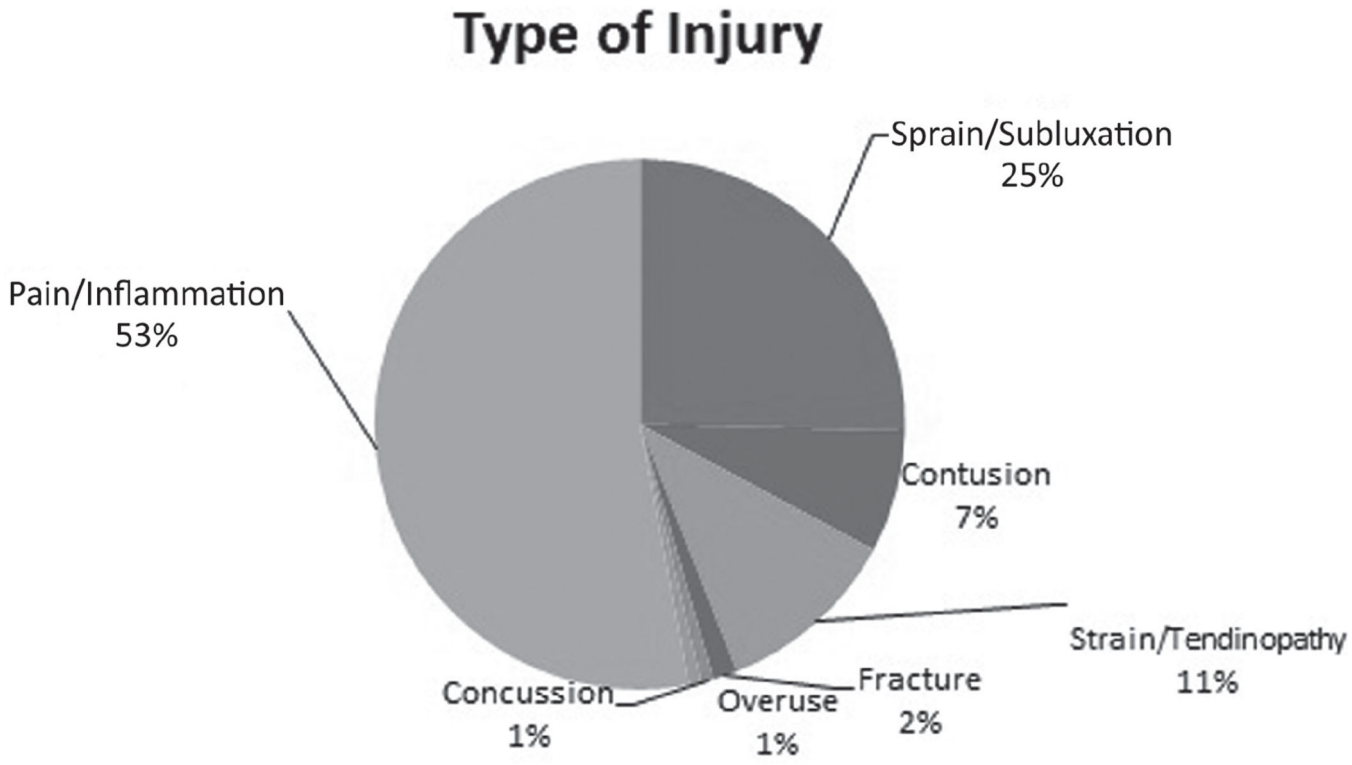

Figure 2.
Injuries by type across all 3 sports.

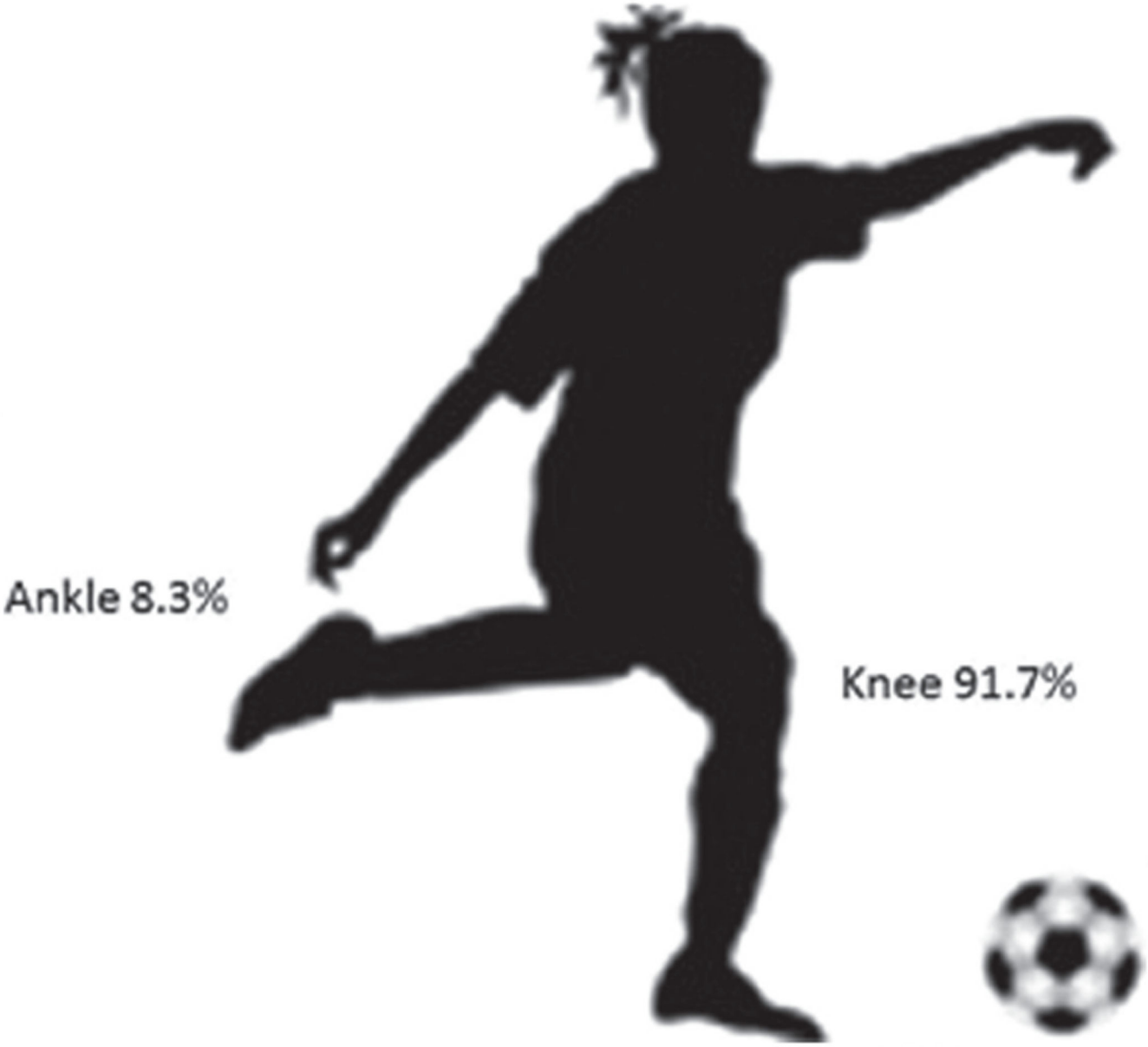

Figure 3.
Soccer injuries by body part.

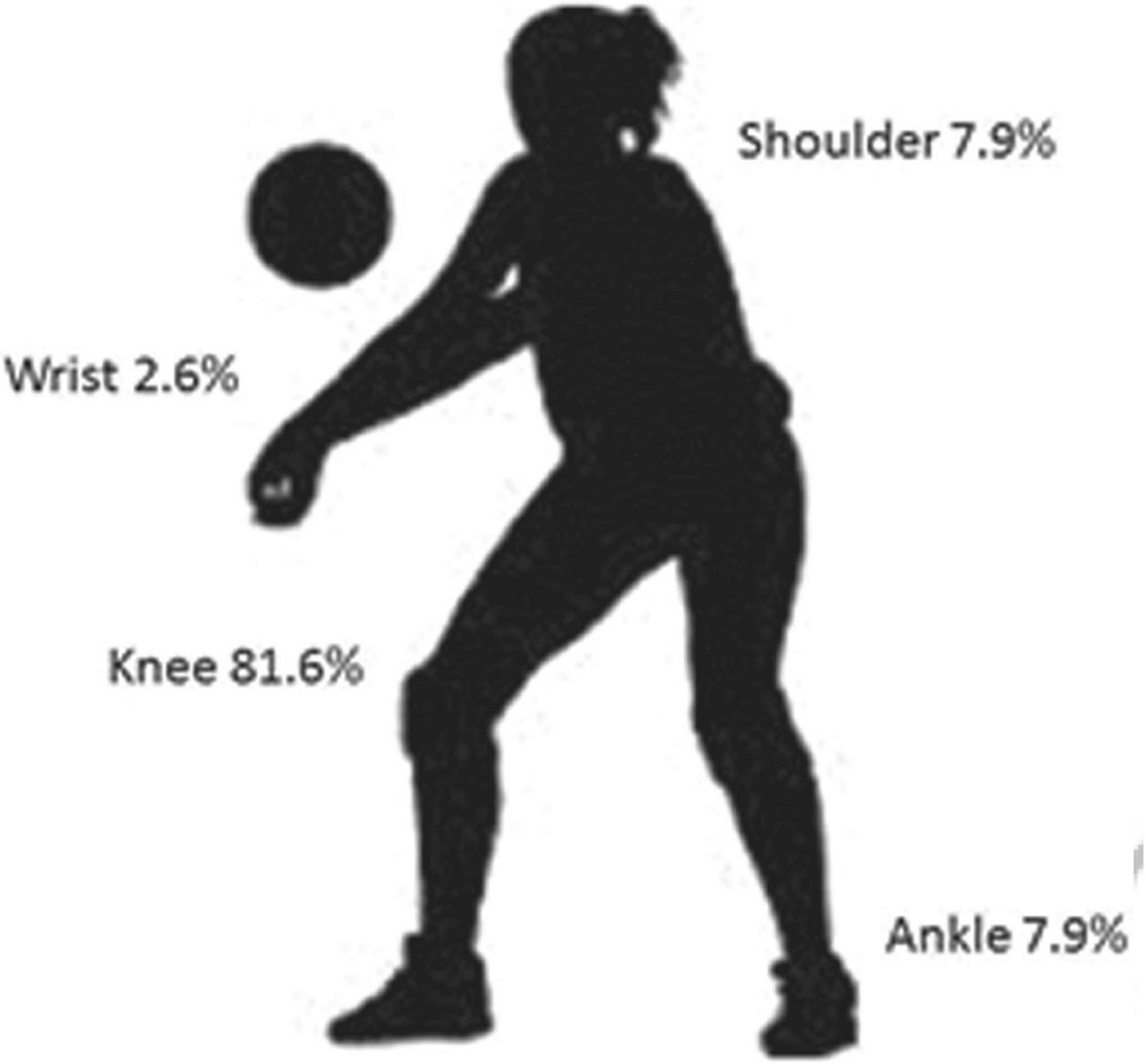

Figure 4.
Volleyball injuries by body part.

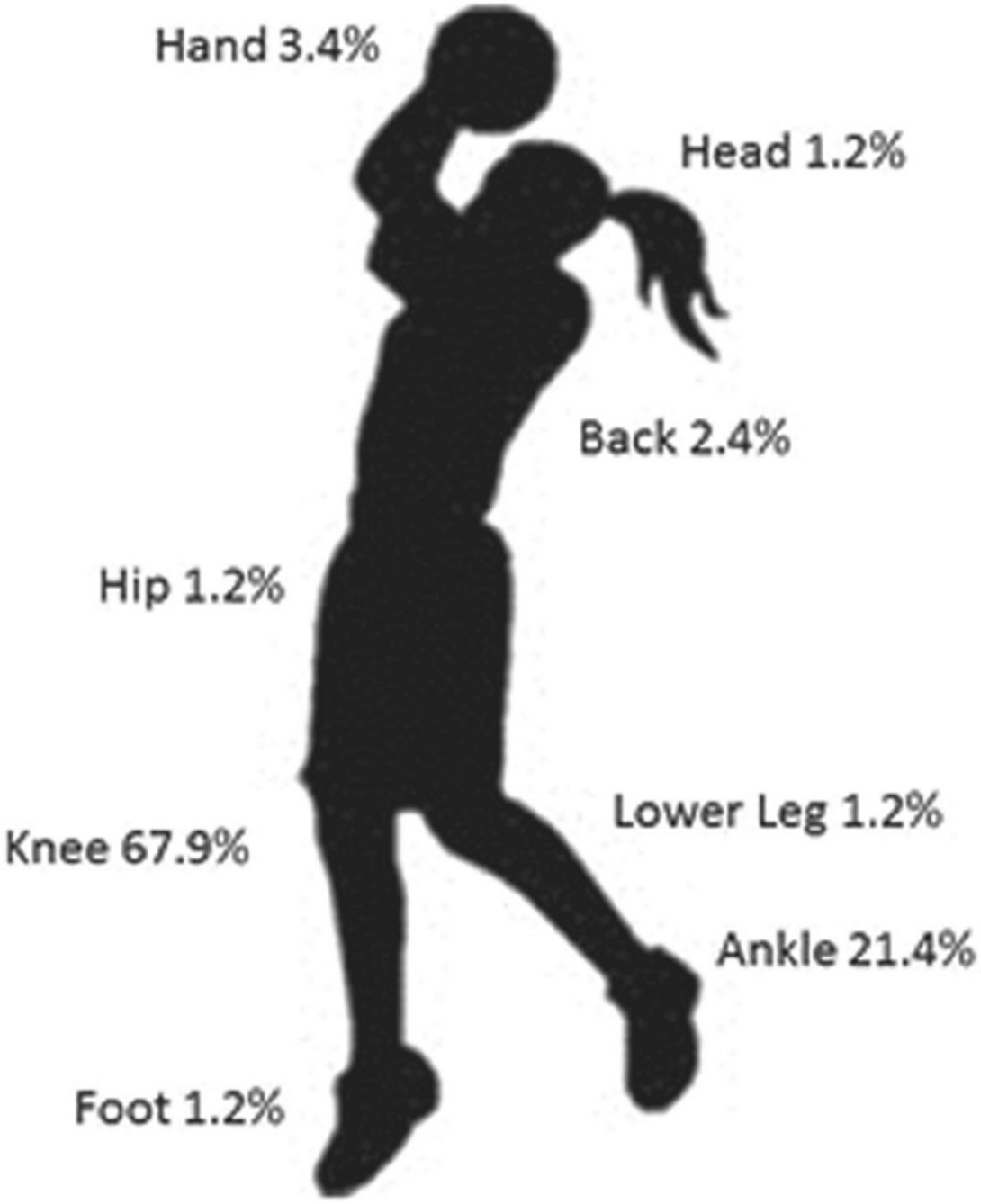

Figure 5.
Basketball injuries by body part.

Table 1

Combined Injuries Across All 3 Sports

	Injuries		Occurrence (N)		Injury Rate[a]	
	N	%	Game	Practice	Game	Practice
Ankle sprain	22	16.4	15	7	1.58	0.25
Foot sprain	1	0.7	0	1	0.07	0.04
Tibia shin splints	1	0.7	0	1	0.07	0.04
Knee contusion	10	7.5	6	4	0.72	0.15
Knee osteochondritis dissecans	2	1.5	1	1	0.14	0.04
Knee pes anserine bursitis	1	0.7	1	0	0.07	0.00
Knee fat pad	6	4.5	4	2	0.43	0.07
Knee sprain	4	3.0	4	0	0.29	0.00
Knee plica	4	3.0	2	2	0.29	0.07
Patellofemoral dysfunction	42	31.3	4	38	3.01	1.38
Sinding-Larsen-Johansson/patella tendinosis	12	9.0	3	9	0.86	0.33
Patella subluxation	4	3.0	2	2	0.29	0.07
Osgood-Schlatter disease	14	10.4	2	12	1.00	0.44
Hip strain	1	0.7	0	1	0.07	0.04
Lumbar sacral strain	2	1.5	2	0	0.14	0.00
Thumb sprain	1	0.7	1	0	0.07	0.00
Finger fracture	2	1.5	1	1	0.14	0.04
Mild brain injury/concussion	1	0.7	0	1	0.07	0.04
Shoulder inflammation	2	1.5	0	2	0.14	0.07
Shoulder subluxation	1	0.7	0	1	0.07	0.04
Wrist sprain	1	0.7	0	1	0.07	0.04
Total	134	100.0	48	86	3.4	3.1

[a]Injury rate per 1000 AEs. Total game AEs = 13 967; total practice AEs = 27 556.

Abbreviation: AE, athlete exposure.

Table 2

Injuries by Body Part

	Injuries (N)	%	Games (N)	Practices (N)	Game	Practice
Ankle/foot	23	17.2	15	8	65.2%	34.8%
Lower leg	1	0.7	0	1	0.0%	100.0%
Knee	99	73.9	29	70	29.3%	70.7%
Hip	1	0.7	0	1	0.0%	100.0%
Back	2	1.5	2	0	100.0%	0.0%
Shoulder	3	2.2	0	3	0.0%	100.0%
Wrist/hand	4	3.0	2	2	50.0%	50.0%
Head	1	0.7	0	1	0.0%	100.0%

Table 3

Injuries by Type

	Injuries (N)	%	Games (N)	Practices (N)	Game	Practice
Sprain/subluxation	34	25.4	22	12	64.7%	35.3%
Contusion	10	7.5	6	4	60.0%	40.0%
Strain/tendinopathy	15	11.2	5	10	33.3%	66.7%
Fracture	2	1.5	1	1	50.0%	50.0%
Concussion	1	0.7	0	1	0.0%	100.0%
Overuse	1	0.7	0	1	0.0%	100.0%
Pain/inflammation	71	53.0	14	57	19.7%	80.3%

Table 4

Soccer Injuries

	Injuries		Occurrence (N)		Injury Rate[a]	
	N	%	Game	Practice	Game	Practice
Ankle sprain	1	8.3	1	0	1.51	0.00
Knee contusion	1	8.3	1	0	1.51	0.00
Knee sprain	1	8.3	1	0	1.51	0.00
Knee fat pad	1	8.3	1	0	1.51	0.00
Patellofemoral dysfunction	4	33.3	0	4	0.00	3.51
Sinding-Larsen-Johansson/Patella Tendinosis	3	25.0	1	2	1.51	1.76
Osgood-Schlatter disease	1	8.3	1	0	1.51	0.00
Total	12	100	6	6	9.05	5.27

[a]Rate per 1000 AEs. Total AEs = 1139; total game AEs = 663.

Abbreviation: AE, athlete exposure.

Phys Sportsmed. Author manuscript; available in PMC 2014 November 03.

Table 5

Basketball Injuries

	Injuries		Occurrence (N)		Injury Rate[a]	
	N	%	Game	Practice	Game	Practice
Ankle sprain	18	21.43	13	5	1.40	0.25
Foot sprain	1	1.19	0	1	0.00	0.05
Tibia shin splints	1	1.19	0	1	0.00	0.05
Knee contusion	8	9.52	4	4	0.43	0.20
Knee osteochondritis dissecans	2	2.38	1	1	0.11	0.05
Knee pes anserine Bursitis	1	1.19	1	0	0.11	0.00
Knee fat pad	4	4.76	3	1	0.32	0.05
Knee sprain	3	3.57	3	0	0.32	0.00
Knee plica	1	1.19	1	0	0.11	0.00
Patellofemoral dysfunction	22	26.19	4	18	0.43	0.89
Sinding-Larsen-Johansson/patella tendinosis	5	5.95	2	3	0.22	0.15
Patella subluxation	3	3.57	2	1	0.22	0.05
Osgood-Schlatter disease	8	9.52	1	7	0.11	0.35
Hip strain	1	1.19	0	1	0.00	0.05
Lumbar sacral strain	2	2.38	2	0	0.22	0.00
Thumb sprain	1	1.19	1	0	0.11	0.00
Finger fracture	2	2.38	1	1	0.11	0.05
Concussion	1	1.19	0	1	0.00	0.05
Total	84	100.00	39	45	4.20	2.24

[a]Injury rate per 1000 AEs. Total practice AEs = 20 113; total game AEs = 9281.

Abbreviation: AE, athlete exposure.

Table 6

Volleyball Injuries

	Injuries		Occurrence (N)		Injury Rate[a]	
	N	%	Game	Practice	Game	Practice
Ankle sprain/fracture	3	7.9	1	2	0.25	0.32
Knee contusion	1	2.6	1	0	0.25	0
Knee plica	3	7.9	1	2	0.25	0.32
Knee fat pad	1	2.6	0	1	0	0.16
Patellofemoral dysfunction	16	42.1	0	16	0	2.54
Sinding-Larsen-Johansson/patella tendinosis	4	10.5	0	4	0	0.63
Patella subluxation	1	2.6	0	1	0	0.16
Osgood-Schlatter disease	5	13.2	0	5	0	0.79
Shoulder inflammation	2	5.3	0	2	0	0.32
Shoulder subluxation	1	2.6	0	1	0	0.16
Wrist sprain	1	2.6	0	1	0	0.16
Total	38	100.0	3	35	0.75	5.55

[a]Injury rate per 1000 AEs. Total game AEs = 4023; total practice AEs = 6304.

Abbreviation: AE, athlete exposure.