DART
Two hours of CDE credit

A literature review of sports-related orofacial trauma

David P. Kumamoto, DDS | Yoshinobu Maeda, DDS, PhD

This literature review evaluates the significance of dental injuries and their relationship to specific sports activities. Many studies have been published on individual sports or groups of sports but most pertain to specific age groups or levels of competition. Research suggests that many sports that do not require mouthguards should encourage male and female participants to use orofacial protectors.

Athletes, coaches, athletic directors, athletic trainers, parents, and members of the dental community should be aware of how individuals who participate in sporting activities are at risk for dental trauma. Any sport where the potential for dental trauma can exist (such as basketball, soccer, or wrestling) should consider utilizing mouthguards to protect the competitors. The establishment of mouthguard programs for athletes of all ages, genders, and sports may help to reduce the incidence of dental trauma. A sports-related, orofacial/dental trauma reporting system is considered.

Received: June 1, 2003 Last revisions: September 8, 2003 Accepted: September 25, 2003

Although mouth protection was introduced to athletes over 100 years ago, only a few sports—including football, boxing, field hockey, ice hockey, and lacrosse—require participants to use mouthguards. Orofacial/dental trauma reporting systems indicate that dental injuries occur in conjunction with athletic activities, particularly the collision and contact sports. Athletes, coaches, and parents continually question the need for protective mouthpieces during sporting activities.[1] As the number of individuals participating in sports has increased, particularly with the enforcement of Title IX, the number of athletes with dental injuries also has increased. Not only do male athletes sustain sports-related dental injuries, female sports participants also are being injured in increasing numbers. The tables in this article were constructed to examine the orofacial injury rates of several common sports.

The injury rates cited by the studies in this article vary greatly from region to region. For example, more information pertaining to dental injuries resulting from rugby accidents was available from Australia, where rugby is a dominant national sport, than from any other country in the world. Dental trauma data also were gathered by different methods in many of the cases, making quantitative comparisons difficult. Many surveys were based on prospective questionnaires given to selected groups of athletes and coaches, while other studies collected data from hospital emergency rooms and dental clinics.

With the information provided in this article, dentists should be able to assist their patient-athletes in determining if a mouthguard is recommended when participating in sports.

Orofacial sports injury studies

Because there is no central data-gathering center for sports-related dental injuries, reports concerning orofacial athletic injuries are scattered throughout the dental literature. The tables presented in this article review some of the studies that have been published over the past 20 years. As the number of individuals involved in sports activities increases, so do the number of athletic dental injuries.[2] Orofacial injuries include soft tissue lacerations, chipped or avulsed teeth, and mandibular/maxillary fractures.

Many of the published studies regarding dental injuries and participation in sports are listed in Table 1. Injury rates vary for a number of reasons; some studies looked at specific groups of athletes and a small sample size caused injury rates to appear high.[3-8] Berg et al reported a high incidence of injury rates due to the number of coaches who reported an injury rather than the true number of injured athletes.[9]

Geographical location resulted in different injury frequencies. For example, Tuli et al reported a high incidence of sports-related dental trauma; alpine skiing accounted for nearly one-third of the oral injuries reported.[10] While Gassner et al confirmed these statistics regarding alpine skiers and maxillofacial trauma, studies by Tanaka et al reported a slightly lower percentage of trauma in Japan.[3,11-13] In Israel, Levin et al studied a group of 850 sports participants aged 6–18 and reported a dental injury rate of 27%.[14]

Sample size also affected the results of the reports. Smaller sample groups were affected more by a slight increase in injury reports compared with a larger pool. For example, Takigawa et al used a sample group of 161 and reported an injury rate of 17.9%, while Nishimura et al reported a higher injury rate (24.2%) using a sample size of 184.[15,16] Other researchers in the same geographical area, whose sample groups ranged from 200 to 1,502, reported injury rates ranging from 9.0–13.8%.[2,4,17-20]

Although athletes may expect to be injured while participating in a specific sport, many of the studies reported that dental/orofacial trauma occurred regularly.[11,21-24] The injury rate varied greatly depending upon the ages of the members of the sample group, the sports involved in the study, and the sample group's geographical location.[25-33] The studies cited in this article were conducted in the United States, Australia, Finland, Sweden, Italy, Austria, Canada, Hungary, Japan, Brazil, Chile, Singapore, Tanzania, New Zealand, and Great Britain.

Basketball

Basketball accounts for many of the orofacial injuries that are reported to dentists and hospital emergency rooms each year.[31] The enforcement of Title IX in the U.S. has led to a dramatic increase in the number of female collegiate athletes.

This increased participation led to more dental injuries in female competitors.[9,34-37] Age-specific studies demonstrate that injury rates in basketball surpass those of collision sports such as football and ice hockey (see Table 2).[30,38-42]

Dental injury rates among basketball players tended to be lower in countries where basketball is not a major sport than they are in the United States.[43] In a survey of Australian basketball players, Cornwell et al reported a high percentage of oral injuries (23%).[44] Of the 114 players who reported an orofacial injury, 21% stated that a mouthguard was worn at the time of injury. Studies conducted in the U.S. by Garon et al (in 1986) and Soporowski et al (in 1994) reported respective injury rates of 11.8% and 12.1%.[29,30] Of two studies conducted in Finland, a 1988 study reported a basketball injury rate of 5.8%, while a 1995 study by Kujala et al reported a rate of 5.2%.[8,45] More recently, Nakanishi et al reported that Japanese basketball players had an injury rate of 2.3%.[46]

Studies that focused on groups of athletes, rather than the general population, showed higher injury rates. Both Ferrari et al and Akemoto et al sampled groups of injured athletes; as a result, the injury rates were greater (36.4% and 11% respectively) than in studies involving the general population.[21,47]

A 1989 study by McNutt et al reported that 40% of basketball and baseball players experienced oral trauma; that same year, Maestrello-deMoya and Primosch reported an injury rate of 31% among high school basketball players.[39,40] A 1995 study of Singapore schoolboys by Teo et al reported an injury rate of 19%.[10] Avulsed teeth were reported as a result of children getting their teeth entangled in basketball nets.[48]

Different surveys indicate that coaches and parents reported that basketball participants experienced dental trauma in high percentages. Berg et al's 1998 study noted injury rates reported by coaches and parents of 85.4% for boys and 78.4% for girls, while Kvittem et al reported injury rates of 54.7% for boys and 56.3% for girls.[9,35] In a 1995 study by Diab and Mourino, 19% of parents reported that one of their children experienced a dental injury.[38] Although these percentages appear extremely high, these numbers reflect the number of coaches and parents who reported injuries and not a true count of the number of dental injuries sustained.

Table 1. Orofacial injury studies.[9-11,14-17,19-33,53,89-101]

Author	Percentage of injury
Levin et al (2003)	27% reported sports-related dental trauma
Gassner et al (2003)	31% of sample had oral trauma
Ferrari et al (2002)	28.8% of study reported trauma
Tuli et al (2002)	31.3% of dentofacial trauma
Gabris et al (2001)	29% sports-related dental injuries
Takigawa et al (2001)	17.9% sports-related trauma
Uchida et al (2001)	10% sports-related trauma
Marcenes et al (2000)	19.2% of dental trauma sports-related
Gassner et al (1999)	50.1% of sample sports-related
Kanoh et al (1999)	11.7% sports-related injuries
Okabe et al (1999)	9.1% sports-related trauma
Iida et al (1998)	9.7% sports-related injuries
Berg et al (1998)	71.5% of coaches reported a dental injury during the course of a season
Kumamoto (1996)	37.4% of athletes in city mouthguard program
Kumamoto et al (1998)	15.4% of dentists in survey
Okamoto et al (1998)	1.3% sports-caused trauma
Borssen and Holm (1997)	35% sports-related
Noda and Hosaka (1997)	8.4% sports trauma
Takeuchi et al (1997)	24.1% pediatric sports-related injuries
Suzuki et al (1997)	11.8% sports injuries
Takeuchi et al (1997)	14.8% sports facial fractures
Ichikawa et al (1996)	12.3% sports-related trauma
Ito et al (1996)	14% chipped teeth sports-related
Moshy et al (1996)	8.6% of facial fractures from sports
Nishimura et al (1996)	24.2% sports-related trauma
Petti and Tarsitani (1996)	20.26% sports-related
Petti et al (1996)	17.4% sports-related
Rodd and Chesham (1996)	26% sports-related
Hayashi et al (1995)	9% sports-related maxillofacial trauma
Hirade et al (1995)	13.80% trauma from sports
Ninomiya et al (1995)	8.8% sports dental injuries
Nukata et al (1995)	2.5% pediatric maxillofacial fractures
Soporowski et al (1994)	37.5% sports-related
Forsberg and Tedestam (1993)	18.2% boys' sports-related dental injuries; 8.2% girls' sports-related dental injuries
Bhat and Li (1987)	25.1% sports and play
Garon et al (1986)	12% of sample reported a dental injury

Female basketball players also have been shown to be at risk for dental trauma. A 1996 study by Gomez et al found that orofacial injuries accounted for 14% of sports injuries from a sample group.[34] A 1989 study by Morrow et al reported that female collegiate players had a 7.5% injury rate while a 1992 study noted that elite players of Olympic caliber during limited competition produced a low injury rate of 1.3%.[36,37,49]

Older athletes tended to have fewer dental injuries than younger players.[37,49,50] A 1991 study by Morrow et al stated that male collegiate players had an injury rate of 10%, while a subsequent study by Lee-Knight et al reported a very low oral injury rate (0.8%) among elite male basketball players during a short tournament period.[41,49] Players who wore mouthguards have a significantly lower dental injury rate than those who wore no protection; however, soft tissue injuries and concussions occurred at similar rates, whether or not mouth protection was worn.[50]

These reports show a clear pattern of orofacial injury for basketball competitors. Injury frequencies are higher for

Table 2. Basketball orofacial injury studies.[8,9,14,29-31,34-36,38-50]

Author	Percentage of injuries
Levin et al (2003)	7% reported basketball-related dental trauma
Cornwell et al (2003)	23% had orofacial injury; 36.4% of study reported trauma
LaBella et al (2002)	0.67/1,000 injuries—no mouthguard; 0.12/1,000 injuries—mouthguard
Nakanishi et al (1999)	2.3% of study reported dental injury
Kvittem et al (1998)	54.7% of boys, 56.3% of girls reported orofacial injury
Berg et al (1998)	85.4% of boys' coaches, 78.4% of girls' coaches
Kumamoto et al (1997)	33 cases of tooth avulsion
Diab and Mourino (1997)	19% reported by parents
Gomez et al (1996)	14% of injuries reported
Akemoto et al (1995)	11% oral injury rate in basketball
Kujala et al (1995)	5.2% of reported total injuries
Teo et al (1995)	19% Singapore schoolboys
Flanders and Bhat (1995)	18.3/100,000 of Illinois sample
Soporowski et al (1994)	12.1% of schoolchildren
Lee-Knight et al (1992)	0.8% of male players; 1.3% of female players
Morrow et al (1991)	10.0% of male collegiate players
Morrow and Bonci (1989)	7.5% of female collegiate players
Maestrello-deMoya and Primosch (1989)	31% of high school players
McNutt et al (1989)	40% of injuries in baseball and basketball
Sane (1988)	5.8% of sample
Bhat and Li (1987)	3.38% hospital emergency room treatment
Garon et al (1986)	11.8% of sample

Table 3. Baseball and softball orofacial injury studies.[9,12,13,19,29-31,36,38,40,46,47,51-53,57]

Author	Percentage of injuries
Mueller et al (2001)	21.3 % of injuries involving ball were dental
Kanoh et al (1999)	22% baseball trauma; 7% softball trauma
Nakanishi et al (1999)	25.2% of injuries from baseball; 5.3% of injuries from softball
Sakamoto (1999)	High school trauma reported
Iida et al (1998)	37% baseball injuries
Berg et al (1998)	75.6% boys baseball; 73.6% girls softball
Diab and Mourino (1997)	17% were baseball-related
Tanaka et al (1996)	12.7% trauma from baseball
Akemoto et al (1995)	22% dental trauma from baseball; 2.5% trauma from softball
Soporowski et al (1994)	21.6% baseball-related
Tanaka et al (1992)	11.2% baseball fracture cases
Morrow and Bonci (1989)	1.6% were softball-related
McNutt et al (1989)	40% baseball- and basketball-related
Garon et al (1986)	12.9% baseball-related
Bhat and Li (1987)	6.68% hospital emergency cases
Nicholas (1980)	2.2% New Zealand schoolchildren

male and female basketball players than for their football counterparts. Although football players are required to wear helmets with face shields and mouthguards at the amateur level (to minimize the risk of dental injury), basketball players have no such mouthguard rule. The authors believe that the dental community should make a strong recommendation for basketball players to use mouthguards to reduce the incidence of dental trauma.

Baseball and softball

Baseball and softball offer greater possibilities for injury; in addition to the possibility of colliding with other players, athletes also can be hit by either a bat or a batted or thrown ball. Many players require emergency medical treatment for baseball-related orofacial injuries.[31] Softball pitchers often are at risk because of their proximity to the batter and the speed with which a batted ball can return to the pitcher.[51] According to a 1998 study, approximately 75% of coaches reported that at least one of their players had sustained a dental injury, although the actual number of injuries may have been very small.[9]

Table 3 summarizes studies regarding baseball-related orofacial trauma. In studies involving Little League and grade school-age players, Diab and Mourino, Soporowski et al, and Mueller et al reported similar findings regarding orofacial trauma.[30,38,52] A 1986 study by Garon et al and a 1989 study by McNutt et al both studied specific groups of athletes and reported significant injury rates among baseball players.[29,40] More recently, Morrow and Bonci reported a 1.6% injury rate among female collegiate softball players, although this low injury rate may result from underreporting.[36]

Regarding dental trauma, studies involving Japanese players indicate that baseball is a riskier sport than softball. Five different studies reported injury rates among baseball players ranging from 12.7–37%.[12,19,46,47,53] Softball injury rates among Japanese women were considerably lower; three studies conducted between 1995 and 1999 reported dental injury rates of 2.5%, 5.3%, and 7.0%.[19,46,47] A variety of factors could contribute to these low injury rates. Softball is a relatively new sport in Japan, a country where female participation in sports is limited. It is possible that the actual number of female athletes is very small compared to male athletes and that the competitive intensity of female athletes is not yet equal to their male counterparts; as a result, fewer injuries are produced.

Older studies tended to find lower injury rates among baseball players, possibly due to geographical region, underreporting of trauma, and studies that did not look at baseball specifically as a target sport.

Although serious injuries have been reported in softball, studies indicate that softball demonstrates a much lower rate of dental trauma than baseball. The authors feel that a recommendation of helmets with the addition of a mouthguard, in a fashion similar to football, should be made to protect baseball and softball players.

Soccer

The increase in participation in soccer among all age groups has resulted in an increased number of dental injuries. The success of U.S. teams in recent World Cup and Olympic competition has increased interest and participation in all parts of the country. The enforcement of Title IX has made it possible for female athletes to compete both on the field and in the classroom.[54]

Soccer orofacial injury rates were similar among male and female athletes (see Table 4).[9,35] Berg et al showed coaches reporting soccer injury rates of 68.3% for boys and 63.2% for girls, while Kvittem et al reported injury rates of 25.6% for boys and 27.3% for girls.[9,35] The significant increase in observed injury rates could be the result of increased soccer participation or possibly a more aggressive reporting system by coaches and parents. In the 2003 study by Levin et al, 6% of the 456 individuals who reported playing soccer sustained dental trauma.[14]

Again, older, collegiate athletes exhibit almost negligible injury rates compared to younger age groups. Two separate studies by Morrow et al reported injury rates of 2.6% for male soccer players and 3.1% for females.[36,41] Six other studies reported injury rates ranging from 2.8–13.8%.[4,10,38,45,55,56]

Small sample sizes resulted in higher injury rates. Six studies with small sample sizes reported injury rates ranging from 9–20%.[10,12,19,46,47,53] In a study that examined 268 injuries sustained by athletes 5–13 years old, Nicholas reported an injury rate of 3% over a six-month period.[57]

Studies that sampled groups of injured athletes only tended to report higher injury percentages compared to dental trauma percentages within the general pool of soccer players.[4,58-60] Emshoff et al reported that 8.9% of sports-related maxillofacial fractures occurred to soccer players.[58] A study conducted one year later stated that 81.8% of the soccer athletes did not think that mouthguards were necessary for the sport.[60]

Table 4. Soccer orofacial injury studies.[4,9,12-14,19,35,36,38,41,42,45-47,53,55-60]

Author	Percentage of injuries
Levin et al (2003)	6.0% reported soccer-related dental trauma
Tuli et al (2002)	8.0% of dentofacial trauma
Kanoh et al (1999)	18% of players reported injury
Nakanishi et al (1999)	13% of group had injury
Iida et al (1998)	10.3% reported injury
Kvittem et al (1998)	25.6% of boys and 27.3% of girls reported orofacial injury
Berg et al (1998)	68.3% of boys' coaches; 63.2% of girls' coaches reported an injury
Yamada et al (1998)	32.3% Japanese schoolchildren
Diab and Mourino (1997)	11% reported by parents
Emshoff et al (1997)	8.9% mandibular fractures
Tanaka et al (1996)	10.8% had oral injury
Akemoto et al (1995)	9% suffered dental trauma
Kujala et al (1995)	2.8% of reported soccer injuries
Teo et al (1995)	20.0% Singapore schoolboys
Tanaka et al (1992)	10.1% of maxillofacial sports fractures
Morrow et al (1991)	2.6% for male collegiate athletes
Morrow and Bonci (1989)	3.1% of female collegiate athletes
Sane and Ylipaavelniemi (1988)	4.5% of injury rate in Finland
Sane and Ylipaavelniemi (1987)	6.4% of injuries were dental
Nysether (1987)	20% of all injuries were dental
Hill et al (1985)	109 of 790 of injuries reported were dental (13.8%)
Nicholas (1980)	3.0% New Zealand schoolchildren

Table 5. Ice hockey, field hockey, and lacrosse orofacial injury studies.[30,36,37,41,45-47,49,55,61-64]

Author	Percentage of injuries
Lahti et al (2002)	50% of damaged teeth were maxillary central incisors
Nakanishi et al (1999)	1.5% reported dental injury
Benson et al (1999)	dental injury rate 9.9 times greater for half shields
Akemoto et al (1995)	1.6% had dental injury
Kujala et al (1995)	7.1% of reported ice hockey injuries
Soporowski et al (1994)	12.7% hockey/lacrosse/field hockey
Lee-Knight et al (1992)	1.3% injury rate for field hockey players
Morrow et al (1991)	2.9% for male collegiate athletes
Morrow et al (1991)	9.8% reported in collegiate hockey
Morrow et al (1989)	2.3% for female athletes
Sane and Ylipaavelniemi (1988)	8.9% of hockey injuries
Sane et al (1988)	11.5% of injuries were dental
Bolhuis et al (1987)	20% of sample reported dental injury

Although the number of soccer dental injuries reported is variable, the authors believe that a recommendation should be made for the use of mouthguards in soccer.

Ice hockey, field hockey, and lacrosse

Ice hockey, field hockey, and lacrosse all require their players to wear mouthguards; even so, studies report that these sports still result in orofacial trauma. The trauma may result from the fact that unlike football, these three sports use both a stick and a solid ball or puck.

Studies conducted between 1988 and 1995 reported ice hockey dental injury rates significantly higher than football

Table 6. Bicycle orofacial injury studies.[4,10,14,22,24,30,31,57,58,66-72]

Author	Percentage of injuries
Levin et al (2003)	6.0% reported bicycle-related dental trauma
Iida and Matsuya (2002)	26% of facial fractures were due to bicycle accidents
Tuli et al (2002)	18.7% of dentofacial trauma (mountain biking 4.9%)
Gabris et al (2001)	13% of injures in bicycle accident
Blinkhorn (2000)	30% of dental trauma bicycle/sports
Marcenes et al (2000)	19.2% of dental trauma bicycle-related
Linn et al (1998)	dental injury 9.9 times greater for helmets
Lombardi et al (1998)	9% of hospital trauma cases
Emshoff et al (1997)	25.4% of mandibular fractures
Acton et al (1996)	39.5% of hospital cases
Thompson et al (1996)	6.6% oral injury
Onetto et al (1994)	9% of reported dental trauma
Soporowski et al (1994)	17.2% were bike/scooter related
Bhat and Li (1987)	13.99% of hospital emergency dental injuries
Hill et al (1985)	5.6% of reported injuries dental
Nicholas (1980)	13% New Zealand schoolchildren

dental injury rates (see Table 5).[41,45,52,61] Benson et al reported in 1999 that players who wore only half-face shields were approximately 10 times more likely to sustain a dental injury than players wearing full-face shields.[62] In a 2002 sample of ice hockey players, Lahti et al found that dental injuries accounted for 11.5% of all reported hockey injuries.[63] Of these dental injuries, 50% of the damaged teeth were maxillary central incisors.

In Japan, where ice hockey is not the most popular sport, a 1995 study reported an injury rate of 1.5%; four years later, Nakanishi et al reported an injury rate that was almost identical (1.6%).[46,47]

Orofacial injury rates were lower for field hockey players than for ice hockey players. A 1987 study by Bolhuis et al sampled 279 international field hockey players competing in three Championship tournaments and noted that 20% had sustained a dental injury.[64] Studies by Morrow et al reported a 2.9% injury rate for male field hockey players and a 2.3% injury rate for female players.[36,41] Lee-Knight et al studied athletes competing in a national tournament and reported a low injury rate of 1.3%.[49] Soporowski et al sampled ice hockey, lacrosse, and field hockey players and reported a combined injury rate of 12.7%.[30]

Although ice hockey, field hockey, and lacrosse require mouthguards and helmets with face shields for men, orofacial injuries from these sports are reported at a higher rate than those incurred in football, a sport that requires similar safety equipment. It is possible that some ice hockey players do not comply with the mouthguard rule and are injured as a result.

Bicycle

The Bicycle Helmet Safety Institute estimates that approximately 85 million Americans ride a bicycle. Approximately 540,000 bike riders end up in the hospital emergency room every year.[65] The orofacial injury rate for bicycle riders has remained relatively stable over the past 20 years.[65] Bicycle helmets are encouraged but using them for protection from dental injuries has not been a major issue.

The majority of reports found higher rates of dental trauma among bicycle riders than among participants in most other sports (see Table 6). The speed at which the rider is traveling and the use of toe clips has put bicycle riders at risk for orofacial trauma.

In a study of Australian hospital cases, Acton et al found that 39.5% of that sample were the result of bicycle accidents.[66] Blinkhorn found that 30% of dental trauma in a group of adolescents in North West England resulted from bicycle accidents.[67] In 1997, Emshoff et al reported that bicycle ride accidents accounted for over 25% of sports-related orofacial fractures in the U.S.[58] Hill et al studied a group of 790 sports-related emergency room hospital patients in the United Kingdom and found that bicycle-related dental trauma accounted for 23.9% of their injuries.[4] In a sample group of 12-year-olds in Brazil, Marcenes et al reported that 19.2% of sports-related dental trauma resulted from bicycle accidents.[24] Tuli et al reported that 18.7% of a sample group reported dental injuries due to bicycle accidents, while another 4.9% sustained orofacial trauma resulting from mountain biking.[10] Levin et al noted that of 205 individuals who sustained an injury while riding a bicycle, 6.0% sustained dental trauma.[14]

A 1994 study of school-age children in Massachusetts, Vermont, Connecticut, and Maine reported that bicycle/scooter accidents were responsible for 17.2% of dental trauma incurred.[30] Bhat and Li reported that among riders who sought treatment at a hospital emergency room, approximately 14% were victims of a bicycle accident.[31] A 1980 study of New Zealand school children by Nicholas reported that 13% of the children had suffered injured teeth due to a bicycle accident, a percentage identical to a 2002 study of Hungarian schoolchildren by Gabris et al.[22,57] A 1997 study of hospital patients in Chile noted that 9% of bicycle accident victims experienced dental trauma; the following year, Lombardi et al's study of a children's hospital in Seattle, Washington reported that 9% of hospital accident cases were bicycle-related.[68,69] A 1996 sample of bicycle riders (collected from hospital emergency rooms in Seattle) reported a dental injury rate of 6.6%.[67] Linn et al studied Canadian bicycle accidents over a period of five years and noted that dental injuries accounted for 5.6% of the total number of injuries.[71] A study conducted by Iida and Matsuya in Japan found that bicycle accidents accounted for 26% of maxillofacial fractures in 174 trauma patients.[72]

Although the injury rates for bicycle-related dental trauma may appear very high, it must be noted that many of the groups were specific trauma samples and that percentages were lower for random samples of the general population groups. Bicycle riding presents a risk of orofacial trauma when participants have an accident; wearing mouthguards and helmets while riding a bicycle could reduce the chance of a dental injury or concussion.

Rugby injury studies

Most rugby studies have been performed in Australia, where rugby is the country's major sport. Rugby is a collision sport that, unlike football in the U.S., does not require protective equipment. The reported dentofacial injury rates for rugby are similar to those of U.S. football from the period before facemasks and mouthguards were mandated (see Table 7).

Yamada et al reported that 56.5% of Japanese high school students who played rugby suffered dental injury as a result.[60] Another Japanese study by Kanoh et al investigated 68 maxillofacial fracture cases and found that 28% of these patients sustained their injuries while playing rugby.[19] Hill et al studied an emergency department in the U.K. over a 12-month period and noted that 26% of maxillofacial injury patients required treatment due to rugby accidents.[4] The authors stated the need for improved safety standards to prevent orofacial trauma.

The following studies were conducted in Japan. A 1996 study by Tanaka et al surveyed 102 athletes with maxillofacial injuries and reported that 24 (23.5%) were rugby players.[12] Three years later, Nakanishi et al found that of 131 athletes who had suffered a maxillofacial injury, 25 (19.1%) were the result of a rugby accident.[46] That same year, Iida et al reported that of 146 patients who had sustained an orofacial injury, 13.8% had done so while playing rugby.[53] Finally, Akemoto et al studied 122 athletes and noted that 15 (12%) had incurred a maxillofacial injury while playing rugby.[47]

A 1999 study by Carson et al examined an elite female rugby team over a 12-month period and determined that the team had 50% fewer injuries than a comparable men's rugby squad.[73] Although this report was not specific about orofacial trauma, the authors stated that injuries occurred at a rate approximately equal to those sustained by women playing other contact and collision sports, specifically soccer and gymnastics.

A 1996 study by Jolly et al reported on four groups of rugby players (a total of 2,611 players) in Victoria, Australia, noting that 25–31% had experienced a dental injury; the injury rate varied by age group.[74] The same study also noted the players' willingness to use mouthguards even though the devices were not required. Some orofacial injuries did occur while players were wearing mouthguards. Hill et al studied an emergency department in the U.K. over a 12-month period and noted that 26% of patients with maxillofacial injuries were the result of rugby accidents.[4] The authors stated the need for improved safety standards to prevent orofacial trauma. Muller-Bolla et al polled French rugby players and reported that 25.97% reported trauma, including dental injuries and facial fractures.[75]

In 1993, Chapman and Nasser surveyed four teams competing at the Second Rugby World Cup Championship (representing Australia, Ireland, Scotland, and Wales) and found that all of the players believed that mouthguards prevented oral injuries.[76] Approximately 20% of these players did not wear a mouthguard even though 50% of the group had experienced a previous oral injury. In another study, the same authors surveyed high school rugby players and noted that 13–15% of players had sustained a previous dental injury and that 30–37% of the players wore mouthguards.[77]

These statistics suggest that educating rugby players about mouthguards has been a partial success. Yamada et al reported that 24.1% of rugby players had a mouthguard and only 26.2% of the players felt that mouthguards were unnecessary.[59] Regardless of geographical residence, mouthguards could protect rugby players from orofacial trauma.

Table 7. Rugby orofacial injury studies.[4,5,12,13,19,46,47,53,57,60,73-77,102,103]

Author	Percentage of injuries
Muller-Bolla et al (2003)	25.97% reported trauma of the lower or middle part of the face
Carson et al (1999)	women's rugby had 50% fewer injuries than men's rubgy
Kanoh et al (1999)	28% had oral trauma
Nakanishi et al (1999)	19.1% had dental injury
Yamada et al (1998)	56.5% Japanese high school students
Iida et al (1998)	17.8% of players reported injury
Chapman and Nasser (1996)	13–15% sport-related
Jolly et al (1996)	25–31% sport-related
Tanaka et al (1996)	23.5% had dental injury
Akemoto et al (1995)	12% of sample reported injury
Chapman and Nasser (1993)	Just under 50% experienced dental injury
Tanaka et al (1992)	24.7% of traumatic fracture patients
Jennings (1990)	71.9% reported injury
Chapman (1990)	40% of British rugby team reported dental injury; 36.4% of U.S. rugby team reported dental injury; 33.3% of Australian rugby team reported dental injury
Hill et al (1985)	206 of 790 (26%) reported dental injury
Chapman (1985)	33.3% 1984 Wallabies; 60.7% 1984 Great Britain Touring Team
Nicholas (1980)	6.7% New Zealand schoolchildren

Football

In the 1950s, it was reported that approximately 54% of all football injuries were orofacial injuries.[78] Through the use of facemasks and mouthguards, the amount of dental injuries among football players has been reduced.[7,31,41,43]

Morrow et al reported a dental injury rate of 2.8% among collegiate football players, while Bhat and Li reported a dental injury rate of 2.73% among patients in a hospital emergency room.[31,41] In a study of registered American football, bandy, basketball, and handball players in Finland, Sane and Ylipaavelniemi found a dental accident rate of 1.4% among football players.[55] By comparison, Flanders and Bhat sampled Illinois high school football players and calculated a dental injury rate of 1.4:100,000.[43]

Mouthguards molded from latex were introduced to football programs on a trial basis until 1962, when they became mandatory in high schools. The National Collegiate Athletic Association (NCAA) adopted a mandatory mouthguard rule in 1973.

From a historical standpoint, even professional football players have had

Table 8. Other sports-related orofacial injury studies.[3,9,10,12,13,17,19,30,35,36,41,42,45-47,49,53,57,82-85,104]

Author	Sport	Percentage of injuries
Tuli et al (2002)	Alpine skiing	31.8% of dentofacial trauma
Gassner et al (2000)	Alpine skiing	41.6% of facial trauma involved teeth; 2% of all ski accidents
Kanoh et al (1999)	Alpine skiing	12% reported dental injury
Nakanishi et al (1999)	Alpine skiing	11.5% experienced injury
Iida et al (1998)	Alpine skiing	5.5% had dental injury
Tanaka et al (1996)	Alpine skiing	22.5% dental trauma
Akemoto et al (1995)	Alpine skiing	16% had oral trauma
Tanaka et al (1992)	Alpine skiing	23.6% of traumatic fracture injuries
Bayliss and Bedi (1996)	Gymnastics	7% hard tissues of the mouth
Soporowski et al (1994)	Gymnastics	5.7% of sample surveryed
Kujala et al (1995)	Judo	2.7% of reported sport injuries
Nakanishi et al (1999)	Karate	3.8% had dental injury
Iida et al (1998)	Karate	6.8% reported injury
Tanaka et al (1996)	Karate	2.9% had orofacial injury
Kujala et al (1995)	Karate	6.4% of reported karate injuries
Hirade et al (1995)	Kendo	8.4% experienced trauma
Kvittem et al (1998)	Wrestling	10% reported a dental injury/season
Teo et al (1995)	Wrestling	33% reported orofacial injury
Persson and Kiliaridis (1994)	Wrestling	15 of 26 experienced orofacial injury
Lee-Knight et al (1992)	Wrestling	1.0% injury rate for Canada Games
Berg et al (1998)	Volleyball	39.0% of girls; 33.3% of boys
Kujala et al (1995)	Volleyball	2.0% of reported total injuries
Morrow et al (1991)	Volleyball	1.2% for male collegiate players
Morrow et al (1989)	Volleyball	1.6% for female collegiate players
Nicholas (1980)	Swimming	10.8% injury rate
Murao et al (1999)	Snowboarding	27.3% of injuries were dental
Wakabayasi et al (1996)	Snowboarding	14% reported dental injury
Frohberg and Bonsmann (1992)	Skateboarding	high percentage of trauma to anterior teeth

dental problems. In 1983, Randell reported that of 34 players on one team, 18 (53%) exhibited untreated trauma, dental caries, periodontal problems, and third molar complications.[79] Even though finances were not an issue, it appeared that these athletes had overlooked their dental condition due to a lack of awareness about dental health. The highest dental injury rate (18.3%) appeared in a 1986 study by Garon et al, the result of 17 of 93 football players reporting a dental injury.[29]

The greatest concern today in football is the serious problem of concussions.[80] Health care professionals are unclear regarding the mechanism that causes concussions and how to make a definitive diagnosis. The role mouthguards play in the prevention of concussions is a controversial issue, particularly among quarterbacks, who appear to be at greater risk for sustaining a concussion.[81]

Other sports

Table 8 lists other sports activities that have reported various percentages of oral trauma among their participants. Most of these sports are low profile but even though the participants do not receive the television coverage, publicity, or large audiences of higher-profile sports, accidents still occur with some regularity.

Alpine skiing accidents can lead to extremely traumatic injuries; a 2000 study of Austrian sports participants (involving 784 patients treated over an eight-year period) reported maxillofacial fractures.[3] It was estimated that dental injuries make up 2% of skiing trauma; luxations, fractured tooth structure, avulsions, soft tissue damage, and fracture of facial bones were the reported sequelae of such accidents.[3] Injuries generally resulted from falls, collisions with other skiers, or skiers making contact with their own equipment. Tuli et al reported that skiing accidents were responsible for 31.8% of the dentofacial trauma that resulted from sports activities.[10] The sample group was located in Austria; as a result, skiing was the predominant sport in this study.

While the study conducted in Austria involved more than 9,000 skiers, studies conducted in Japan used relatively small sample groups, resulting in skiing-related orofacial injury rates ranging from 5.5–23.6%.[12,13,19,46,47,53]

Gymnasts do not demonstrate a large dental injury rate but accidents do occur. Soporowski et al found that a small percentage of athletes sustained orofacial trauma, while Tuli et al reported a low injury rate (2.1%) in the group that was surveyed.[10,30] These injuries are particularly unique since gymnasts do not come into physical contact with other competitors or projectiles such as balls, pucks, or bats. Bayliss and Bedi reported that most accidents that resulted in dental injury involved more advanced level gymnasts and most of the injuries occurred during practice rather than competition.[82]

Martial arts exhibit a small but significant percentage of dental trauma. Studies conducted between 1995 and 1999 reported that injuries occurred among participants in judo, karate, and kendo.[12,17,45,46,53] Since physical contact with a competitor is the primary focus of these sports, some trauma might be expected. Mouthguards have been recommended for martial artists.

Boxing and wrestling resulted in a significant number of dental injuries. Kvittem et al found that the chance of one wrestler sustaining a dental injury during a season was 72.3%, while Persson and Kiliaridis discovered that more than 50% of the wrestlers they interviewed had experienced some oral trauma.[35,83] A sample of Singapore schoolboys reported that boxing and wrestling resulted in 33% of dental injuries.[10] Wrestlers, soccer players, and basketball players wearing orthodontic appliances also were more likely to suffer an injury.[35]

Volleyball generally demonstrated a low rate of dental trauma. Morrow et al and Kujala et al both reported low rates for dental injuries.[36,41,45] Berg et al noted coaches who indicated that players were injured while playing volleyball but the percentages reflected only the number of coaches who indicated that a player was

injured over the course of a season.[9] Volleyball appears to be less risky than most other competitive sports regarding orofacial injuries.

According to the 1980 study by Nicholas et al, swimming had a surprisingly high injury rate.[57] It was not clear if these swimmers were recreational or competitive; for example, water polo players might expect to experience a high injury rate.

So-called "extreme" recreational activities such as skateboarding and snowboarding also have demonstrated significant rates of dental injury. A 1999 study of Japanese snowboarders reported a 27.3% dental injury rate; by comparison, a 1996 study by Wakabayshi et al found that 14% of the sample group experienced some type of dental trauma while snowboarding.[84,85]

Contact sports (including the martial arts) should consider the use of mouth protectors to minimize the chance of orofacial injury. Non-contact recreational sports like skiing, gymnastics, skateboarding, and snowboarding also demonstrate a risk for dental trauma. Using a mouthguard for these activities may benefit participants.

Orofacial injury site studies

Individuals participating in sports activities may be at risk for dentofacial trauma. The literature indicates that the maxillary central incisors are injured more frequently than any other teeth (see Table 9).[10,22,25-27,55-57,59,68] Other non-sports events, such as falls, automobile accidents, fighting, and work injuries, also can result in trauma to the maxillary front teeth.

The rate of injury is relatively similar regardless of the sport involved or the geographic region. The countries listed in Table 9 include Norway, Finland, Hungary, Italy, New Zealand, Singapore, Sweden, and the U.S.; the sports involved include soccer, football, bandy, ice hockey, wrestling, and basketball.

The use of a mouthguard may protect the maxillary front teeth from injury. Labella et al reported a significant difference in the injury rates of basketball players who wore mouthguards compared with players who did not.[50] Football has demonstrated a dramatic decrease in dental injuries with the use of mouthguards and helmets with facemasks. The use of mouthguards in all sports would reduce the chance of dental injury for an athlete.

Table 9. Teeth injured most frequently in sports activities.[22,25-27,42,57,59,69]

Author	Percentage of injuries
Gabris et al (2001)	85.87% maxillary central incisors
Lombardi et al (1998)	87% maxillary permanent incisors
Borsen and Holm (1997)	75% maxillary incisors
Petti and Tarsitani (1996)	62% maxillary central incisors
Petti et al (1996)	74.6% maxillary central incisors
Teo et al (1995)	64.8% maxillary incisors damaged
Nysether (1987)	45% of injuries affected maxillary anterior teeth
Nicholas (1980)	72.4% maxillary central incisors

Mouthguard historical timeline

The first reported mouthguard was made by Woolf Krause in 1892.[86] Dental literature does not mention mouthpieces again until 1915, when professional boxer Ted "Kid" Lewis is reported to have used a mouthguard during a championship bout. On February 7, 1921, Lewis fought Jack Britton, whose camp protested Lewis' use of a mouthpiece. Shortly after the match, boxing officials declared mouthguards illegal; however, officials later changed their ruling and mouthguards have become a part of regular boxing equipment.[86]

In the 1950s, several dental societies started making mouthguards for football teams. Prior to this, approximately 50% of all football injuries were dental. The National Alliance Football Rules Committee adopted a mandatory mouthguard rule for high schools and junior colleges in 1962 and the NCAA added mouthguards to the list of mandatory football equipment in 1973.[87]

USA Hockey, the national governing body for the sport of hockey in the U.S., adopted a mandatory mouthguard rule in 1975. Today, most amateur levels of ice hockey, including youth leagues, high school, and college, require the use of mouthguards; however, it is the authors' experience that many professional players refuse to wear intraoral mouth protection.

In 1983, a group of dentists who had worked with athletes and mouthguards at amateur and professional levels founded the Academy for Sports Dentistry. This organization was created for individuals who were interested in sports and dentistry to exchange ideas, stimulate research, and promote the concept of orofacial protection through the use of mouthguards. This group has expanded and now has many international members.

As of 2003, football, boxing, ice hockey, field hockey, and lacrosse are the only sports in the U.S. that require players to use a mouthguard. For sports where a dental injury might occur, such as rugby and basketball, athletes use mouth protection on a limited, voluntary basis.

Summary

Studies show that sports are the cause of many dental injuries and that trauma rates vary for many reasons. Different age groups exhibit different injury rates, collision sports have different rates than contact sports, and the various levels of competition (that is, professional and amateur) result in a wide range of facial injury rates. Different cultures place more emphasis on certain sports; for example, Australia emphasizes rugby while the U.S. has more intense competition in football. As a result, these studies note higher injury rates for these sports. Over time, injury rates have decreased in some sports such as football and ice hockey due to the requirement and improvement of protective equipment, such as facemasks and mouthguards.

In some cases, injury rates have increased as more individuals participate in a specific sport. For example, Title IX has increased the participation of female athletes in the United States at all levels of competitive and recreational activities.

Mandibular fractures also occur with some frequency in high-velocity sports, such as bicycle riding and alpine skiing; snowboarding and skateboarding are relatively new sports that also account for orofacial trauma.

A far-reaching, recording mechanism has been recommended to create a more

significant database.[88] Whether this recording is performed at a national or an international level, it could provide more accurate information for anyone looking for information about a specific sport. Incidents could be recorded on an ongoing basis rather than retrospectively, making the data more reliable and accurate.

Comparing injury statistics can be difficult as there is no uniform system for reporting the number of injuries. Some studies report injuries per 1,000, 10,000, or 100,000 incidents, while other studies report injuries based on percentages of the sample group; the small size of the target population means that these numbers may be inaccurate. Conversely, these statistics may be lower than expected because the athletes affected may not report all of their injuries.

The importance of orofacial protection should be stressed to the general population by members of the dental profession. Mouthguards have been shown to reduce the number of dental injuries. Mouthguard programs, as fee-for-service entities or voluntary public service projects, benefit both the athletes and the dentists involved. These programs promote dentistry and enhance the image of the profession in the community.

Author information

Dr. Kumamoto is a clinical associate professor, College of Dentistry, University of Illinois at Chicago. Dr. Maeda is a professor and Head, Division of Interdisciplinary Dentistry, Osaka University, Japan.

References

1. Gardiner DM, Ranalli DN. Attitudinal factors influencing mouthguard utilization. Dent Clin North Am 2000;44:53-65.
2. Guyette RF. Facial injuries in basketball players. Clin Sports Med 1993;12:247-264.
3. Gassner R, Vasquez Garcia J, Leja W, Stainer M. Traumatic dental injuries and Alpine skiing. Endod Dent Traumatol 2000;16: 122-127.
4. Hill CM, Crosher RF, Mason DA. Dental and facial injuries following sports accidents: A study of 130 patients. Br J Oral Maxillofac Surg 1985;23:268-274.
5. Jennings DC. Injuries sustained by users and non-users of gum shields in local rugby union. Br J Sports Med 1990;24:159-165.
6. Kiriyama T, Yoshiga K. Clinico-statistical analysis of maxillofacial fractures (in Japanese). J Jpn Stomatol Soc 1995;44:202-206.
7. National Collegiate Athletic Association. Injury surveillance data notebook 1999-2000. Indianapolis, IN: NCAA Health and Safety;2001.
8. Sane J. Comparison of maxillofacial and dental injuries in four contact team sports: American football, bandy, basketball, and handball. Am J Sports Med 1988;16:647-651.
9. Berg R, Berkey DB, Tang JM, Altman DS, Londeree KA. Knowledge and attitudes of Arizona high-school coaches regarding oral-facial injuries and mouthguard use among athletes. J Am Dent Assoc 1998;129: 1425-1435.
10. Tuli T, Hachl O, Hohlrieder M, Grubwieser G, Gassner R. Dentofacial trauma in sport accidents. Gen Dent 2002;50:274-279.
11. Gassner R, Tuli T, Hachl O, Rudisch A, Ulmer H. Cranio-maxillofacial trauma: A 10 year review of 9,543 cases with 21,067 injuries. J Craniomaxillofac Surg 2003;31:51-61.
12. Tanaka N, Kimijima Y, Sato M, Shionoya K, Amagasa T. Clinicostatistical observation of sports-related maxillofacial fractures (in Japanese). Jpn J Oral Maxillofac Surg 1996; 42:314-316.
13. Tanaka N, Hayashi S, Suzuki K, Uchide N, Tomitsuka K, Hirata Y, Yoshimasu H, Amagasa T. [Clinical study of maxillofacial fractures sustained during sports and games]. Kokubyo Gakkai Zasshi 1992;59:571-577.
14. Levin L, Friedlander LD, Geiger SB. Dental and oral trauma and mouthguard use during sport activities in Israel. Dent Traumatol 2003;19:237-242.
15. Takigawa T, Honda M, Uehara H, Fujita S, Takahashi K, Ito Y, Sukegawa H, Ohki H, Sekiwa T, Terakado M, Sato H, Honda K, Hashimoto K. Clinical-statistical observation of maxillofacial trauma, Part 1. Trends, patients, and diagnoses during the past 5 years. Nichikohshinshi 2001;14:322-333.
16. Nishimura N, Iida S, Takeda M, Sakai T, Kimura T. Clinical statistics on bone fracture in maxiilofacial region treated at the 2nd department of oral surgery of Osaka University (in Japanese). J Osaka Univ Dent Sch 1996;41:232-239.
17. Hirade T, Tomita F, Ozawa H, Suzawa T, Arishita T, Chen QR, Shibasaki Y. Sports injury and malocclusion/function in the young generation: A questionnaire of 514 3rd grade students of a senior high school (in Japanese). Proceedings of the 6th Japan Society for Sports Dentistry;1995:61-96.
18. Hirano M, Horikawa M, Takano M, Kasahara K, Saito S, Oda M. Clinical study maxillofacial fractures in the dentistry and oral and maxillofacial surgery (in Japanese). Hokkaido J Dent Sci 1996;17:346-353.
19. Kanoh Y, Nukata J, Michizawa M, Matsumoto R, Matsuyama H. Clinicostatistical study of 68 cases maxillofacial fractures caused by sports. JJTON 1999;47:766-769.
20. Suzuki M, Toujyo N, Kato T, Nasu D, Kaneko, Shimoyama T. Clinical statistical analysis on bone fracture related to sports injuries. J Jpn Soc Clinical Sports Med 1997;14:593-596.
21. Ferrari CH, Ferreria de Mederios JM. Dental trauma and level of information: Mouthguard use in different contact sports. Dent Traumatol 2002;18:144-147.
22. Gabris K, Tarjan I, Rozsa N. Dental trauma in children presenting for treatment at the Department of Dentistry for Children and Orthodontics, Budapest, 1985-1999. Dent Traumatol 2001;17:103-108.
23. Kumamoto DP, Meleedy-Rey P, Thayer-Doyle C. Project Mouthguard: A survey of Illinois dentists' attitudes on mouthguards. CDS Rev 1998;91:28-33.
24. Marcenes W, Alessi ON, Traebert J. Causes and prevalence of traumatic injuries to the permanent incisors of school children aged 12 years in Jaragua do Sul, Brazil. Int Dent J 2000;50:87-92.
25. Borssen E, Holm AK. Traumatic dental injuries in a cohort of 16-year-olds in northern Sweden. Endod Dent Traumatol 1997; 13:276-280.
26. Petti S, Tarsitani G, Arcadi P, Tomassini E, Romagnoli L. [The prevalence of anterior tooth trauma in children 6 to 11 years old.] Minerva Stomatol 1996;45:213-218.
27. Petti S, Tarsitani G. Traumatic injuries to anterior teeth in Italian schoolchildren: Prevalence and risk factors. Endod Dent Traumatol 1996;12:294-297.
28. Rodd HD, Chesham DJ. Sports-related oral injury and mouthguard use among Sheffield school children. Community Dent Health 1997;14:25-30.
29. Garon MW, Merkle A, Wright JT. Mouth protectors and oral trauma: A study of adolescent football players. J Am Dent Assoc 1986;112:663-665.
30. Soporowski NJ, Tesini DA, Weiss AI. Survey of orofacial sports-related injuries. J Mass Dent Soc 1994;43:16-20.
31. Bhat M, Li SH. Consumer product-related tooth injuries treated in hospital emergency rooms: United States, 1979-87. Community Dent Oral Epidemiol 1987;18:133-138.
32. Forsberg CM, Tedestam G. Etiological and predisposing factors related to traumatic injuries to permanent teeth. Swed Dent J 1993;17:183-190.
33. Moshy J, Mosha HJ, Lema PA. Prevalence of maxillo-mandibular fractures in mainland Tanzania. East Afr Med J 1996;73:172-175.
34. Gomez E, DeLee JC, Farney WC. Incidence of injury in Texas girls' high school basketball. Am J Sports Med 1996;24:684-687.
35. Kvittem B, Hardie NA, Roettger M, Conry J. Incidence of orofacial injuries in high school sports. J Public Health Dent 1998; 58:288-293.
36. Morrow RM, Bonci T. A survey of oral injuries in female college and university athletes. Athletic Training JNATA 1989;24:236-237.

37. Morrow RM, Bonci T, Seal JR, Barnwell GM. Oral injuries in southwest conference women basketball players. Athletic Training JNATA 1991;26:344-345.
38. Diab N, Mourino AP. Parental attitudes toward mouthguards. Pediatr Dent 1997;19: 455-460.
39. Maestrello-deMoya MG, Primosch RE. Orofacial trauma and mouth-protector wear among high school varsity basketball players. ASDC J Dent Child 1989;56:36-39.
40. McNutt T, Shannon SW Jr, Wright JT, Feinstein RA. Oral trauma in adolescent athletes: a study of mouth protectors. Pediatr Dent 1989;11:209-213.
41. Morrow RM, Seals RR, Barnwell GM, Day EA, Moore RN, Stephens MK. Report of a survey of oral injuries in male college and university athletes. Athletic Training JNATA 1991;26:339-342.
42. Teo CS, Stokes AN, Loh T, Bagramian RA. A survey of tooth injury experience and attitudes to prevention in a group of Singapore schoolboys. Ann Acad Med Singapore 1995;24:23-25.
43. Flanders RA, Bhat M. The incidence of orofacial injuries in sports: A pilot study in Illinois. J Am Dent Assoc 1995;126:491-496.
44. Cornwell H, Messer LB, Speed H. Use of mouthguards by basketball players in Victoria, Australia. Dent Traumatol 2003;19: 193-203.
45. Kujala UM, Taimela S, Antti-Poika I, Orava S, Tuominen R, Myllynen P. Acute injuries in soccer, ice hockey, volleyball, basketball, judo, and karate: Analysis of national registry data. BMJ 1995;311:1465-1468.
46. Nakanishi C, Nukata J, Ide S, Doi T, Matsuyama H, Matsumura T, Yamada T, Fujimoto K, Sakuda M. Clinical characteristics of 131 patients with sports-related oral and maxillofacial injuries. Jpn J Oral Maxillofac Surg 1999;45:208-210.
47. Akemoto Y, Fukuta K, Takano M, Yamaguti H, Nishikata S, Totsuka Y, Kida M, Fukuda H. A clinical study of sports related maxillofacial injuries. Proceedings from the 6th meeting of the Japan Sports Dental Society;1995:65-68 (in Japanese).
48. Kumamoto DP, Winters J, Novickas D, Mesa K. Tooth avulsions resulting from basketball net entanglement. J Am Dent Assoc 1997;128:1273-1275.
49. Lee-Knight CT, Harrison EL, Price CJ. Dental injuries at the 1989 Canada games: An epidemiological study. J Can Dent Assoc 1992;58:810-815.
50. Labella CR, Smith BW, Sigurdsson A. Effect of mouthguards on dental injuries and concussions in college basketball. Med Sci Sports Exer 2002;34:41-44.
51. Sakamoto B. In high school play, a livelier softball may be adding insult to injury. *Chicago Tribune*. May 13, 1999.
52. Mueller FO, Marshall SW, Kirby DP. Injuries in Little League baseball from 1987 through 1996. Physician Sportsmedicine 2001;29:41-48.
53. Iida S, Nomura K, Sugimura T, Nakashima M, Adachi T, Kogo M, Matsuya T. Clinical observation of 146 cases of sports-related oral and maxillofacial fractures (in Japanese). Jpn J Oral Maxillofac Surg 1998;44: 805-807.
54. U.S. Department of Education. Title IX: 25 years of progress. Washington, DC: U.S. Department of Education;1997.
55. Sane J, Ylipaavalniemi P. Dental trauma in contact team sports. Endod Dent Traumatol 1988;4:164-169.
56. Sane J, Ylipaavalniemi P. Maxillofacial and dental soccer injuries in Finland. Br J Oral Maxillofac Surg 1987;25:383-390.
57. Nicholas NK. Dental injuries in primary and intermediate school children. N Z Dent J 1980;76:8-11.
58. Emshoff R, Schoning H, Rothler G, Waldhart E. Trends in the incidence and cause of sport-related mandibular fractures: A retrospective analysis. J Oral Maxillofac Surg 1997;55:585-592.
59. Nysether S. Dental injuries among Norwegian soccer players. Community Dent Oral Epidemiol 1987;15:141-143.
60. Yamada T, Sawaki Y, Tomida S, Tohnai I, Ueda M. Oral injury and mouthguard usage by athletes in Japan. Endod Dent Traumatol 1998;14:84-87.
61. Sane J, Ylipaavalniemi P, Leppanen H. Maxillofacial and dental ice hockey injuries. Med Sci Sports Exerc 1988;20:202-207.
62. Benson BW, Mohtadi NG, Rose MS, Meeuwisse WH. Head and neck injuries among ice hockey players wearing full face shields vs half face shields. JAMA 1999;282: 2328-2232.
63. Lahti H, Sane J, Ylipaavalniemi P. Dental injuries in ice hockey games and training. Med Sci Sports Exerc 2002;34:400-402.
64. Bolhuis JH, Leurs JM, Flogel GE. Dental and facial injuries in international field hockey. Br J Sports Med 1987;21:174-177.
65. A compendium of statistics from various sources. Available at: http://www.bhsi.org /stats.htm. Accessed April 17, 2004.
66. Acton CH, Nixon JW, Clark RC. Bicycle riding and oral/maxillofacial trauma in young children. Med J Aust 1996;165:249-251.
67. Blinkhorn FA. The aetiology of dento-alveolar injuries and factors influencing attendance for emergency care of adolescents in the north west of England. Endod Dent Traumatol 2000;16:162-165.
68. Onetto JE, Flores MT, Garbarino ML. Dental trauma in children and adolescents in Valparaiso, Chile. Endod Dent Traumatol 1994;10:223-227.
69. Lombardi S, Sheller B, Williams BJ. Diagnosis and treatment of dental trauma in a children's hospital. Pediatr Dent 1998;20: 112-120.
70. Thompson DC, Nunn ME, Thompson RS, Rivara FP. Effectiveness of bicycle safety helmets in preventing serious facial injury. JAMA 1996;276:1974-1975.
71. Linn S, Smith D, Sheps S. Epidemiology of bicycle injury, head injury, and helmet use among children in British Columbia: A five year descriptive study. Canadian Hospitals Injury, Reporting and Prevention Program (CHIRPP). Inj Prev 1998;4:122-125.
72. Iida S, Matsuya T. Paediatric maxillofacial fractures: Their aetiological characters and fracture patterns. J Craniomaxillofac Surg 2002;30:237-241.
73. Carson JD, Roberts MA, White AL. The epidemiology of women's rugby injuries. Clin J Sport Med 1999;9:75-78.
74. Jolly KA, Messer LB, Manton D. Promotion of mouthguards among amateur football players in Victoria. Aust N Z J Public Health 1996;20:630-639.
75. Muller-Bolla M, Lupi-Pegurier L, Pedeutour P, Bolla M. Orofacial trauma and rugby in France: Epidemiological survey. Dent Traumatol 2003;19:183-192.
76. Chapman PJ, Nasser BP. Attitudes to mouthguards and prevalence of orofacial injuries in four teams competing at the second Rugby World Cup. Br J Sports Med 1993;27:197-199.
77. Chapman PJ, Nasser BP. Prevalence of orofacial injuries and use of mouthguards in high school Rugby Union. Aust Dent J 1996;41:252-255.
78. Cathcart JF. Essential in contact sports. Mouth protection—A must for football players. Dent Survey 1952;28:195-199.
79. Randell S. Dental trauma and disease in 34 professional athletes. Phys Sportsmed 1983;11:85-91.
80. Barth JT, Freeman JR, Winters JE. Management of sports-related concussions. Dent Clin North Am 2000;44:67-83.
81. Pellman EJ, Powell JW, Viano DC, Casson IR, Tucker AM, Feuer H, Lovell M, Waeckerle JF, Robertson DW. Concussion in professional football: epidemiological features of game injuries and review of the literature—Part 3. Neurosurgery 2004;54:81-94.
82. Bayliss T, Bedi R. Oral, maxillofacial and general injuries in gymnasts. Injury 1996; 27:353-354.
83. Persson LG, Kiliaridis S. Dental injuries, temporomandibular disorders, and caries in wrestlers. Scand J Dent Res 1994;102:367-371.
84. Murao Y, Shigemoto S, Okita M, Shigemoto M, Watanabe K, Matsuura Y. Statistical analysis on traumatic injuries during snowboarding. J Hiroshima Med 1999;52:572-575.
85. Wakabayashi T, Fujiwara T, Mori K, Kondo A, Kan H, Irie K, Inoue K. Injuries during snow boarding: Comparison with those during skiing. J Jpn Soc Clin Sports Med 1996;13:1187-1192.

86. Reed RV Jr. Origin and early history of the dental mouthpiece. Br Dent J 1994;176: 478-480.
87. Powers JM, Godwin WC, Heintz WD. Mouth protectors and sports team dentists. Bureau of Health Education and Audiovisual Services, Council on Dental Materials, Instruments, and Equipment. J Am Dent Assoc 1984;109:84-87.
88. Tesini DA, Soporowski NJ. Epidemiology of orofacial sports-related injuries. Dent Clin North Am 2000;44:1-18.
89. Uchida T, Nakamura E, Suzuki T, Amano D, Kobori Y, Matsushita K, Horimukai H, Fujiwara T. A clinicostatistical study of maxillofacial fractures in the Department of Dentistry and Oral Surgery, Sapporo General Hospital, Hokkaido. J Dent Sci 2001;22:37-43.
90. Gassner R, Bosch R, Tuli T, Emshoff R. Prevalence of dental trauma in 6000 patients with facial injuries: Implications for prevention. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;87:27-33.
91. Okabe K, Miyata M, Saito K, Takagi J, Sakashita H. Clinical study of maxillofacial fractures on the pediatric 22 patients. Pediatr Oral Maxillofac Surg 1999;2:45-50.
92. Kumamoto D. Project Mouthguard: Survey of Illinois dentists' attitude on mouthpieces. Research Forum Oral Presentation. Presented at American Dental Association/ FDI World Dental Congress. Orlando, FL: September 29, 1996.
93. Okamoto K, Matsuhira J, Kawashima T, Morita N, Sakamoto T. Clinical statistics on bone fracture in maxiilofacial region at the department of oral surgery of Kokuho Hashimoto Shimin Hospital. J Wakayama Med 1998;49:113-116 (in Japanese).
94. Noda K, Hosaka Y. A statistical study of zygomatic bone fracture that we experienced during the past 5 years. JJTON 1997;8:501-504.
95. Takeuchi J, Nakanishi C, Michisawa M, Kano Y, Matsumoto R, Fujishiro H, Ota Y, Adachi M, Sakuda M. Clinico-statistical observation on 270 teeth injuries in pediatric patients. Pediatr Oral Maxillo Surg 1997;1:16-21 (in Japanese).
96. Takeuchi M, Goto Y, Ozeki K, Hayashi Y. Clinical statistics on bone fractured hospitalized cases in maxiilofacial region at the department of oral surgery of Nagoya 2nd Red Cross Hospital Hokkaido. J Dent Sci 1997;18:147-152.
97. Ichikawa T, Yoshiga K, Komatsu D, Ohtsuki T, Tsumura M, Takada K. Clinicostatistical study of 855 cases of maxillofacial fractures. Jpn J Oral Maxillofac Surg 1996;42:1218-1220 (in Japanese).
98. Ito H, Sekiguchi T, Kawamura S, Murota K, Murata A, Hirano M, Hiratsuka H, Nagai I, Kohama G. A clinical study of 135 cases of molar complex fractures. Jpn J Oral Maxillofac Surg 1996;42:317-319 (in Japanese).
99. Hayashi A, Ohtsuki K, Ishibe K, Tsuji M, Ohnishi M. Clinicostatistical survey of sports-related maxillofacial injuries in our department. Proceedings from the 6th meeting of Japan Sports Dentistry Society;1995:71-73 (in Japanese).
100. Ninomaya T, Masuda S, Kubota Y, Fujimura K, Ishibashi H, Takenoshita Y. Recent trend in orofacial injuries on sports. Proceedings of the 6th meeting of the Japan Sports Dental Society;1995:62-65 (in Japanese).
101. Nukata J, Matsumoto R, Kamifusa T, Ota Y, Adachi M, Fujishiro H, Kano Y, Jotoku Y, Sakuda M. A clinico-statistical study of 40 cases with pediatric maxillofacial fractures. Pediatr Oral Maxillo Surg 1995:1:1-8 (in Japanese).
102. Chapman PJ. Orofacial injuries and international rugby players' attitudes to mouthguards. Br J Sports Med 1990;24:156-158.
103. Chapman PJ. Orofacial injuries and mouthguards: A study of the 1984 Wallabies. Br J Sports Med 1985;19:93-95.
104. Frohberg U, Bonsmann M. [Orofacial injuries in skateboard accidents]. Aktuelle Traumatol 1992;22:84-86.

Exercise No. 141
Subject Code: 154

Sports Dentistry

The 15 questions for this exercise are based on the article, "A literature review of orofacial sports injuries" on pages 270–280. This exercise was developed by Wilferd B. Vachon Jr., DMD, MAGD, in association with the *General Dentistry* DART Committee.

Reading the article and successfully completing this exercise will enable you to:

- understand the dental risks associated with specific sports;
- understand the importance of orofacial protection afforded by mouthguards;
- recognize the patterns of orofacial injuries associated with certain sports; and
- assist the patient-athlete in determining the appropriateness of a mouthguard.

Answer form and instructions are on pages 255-256.

1. This study encompassed the past
   A. 10 years.
   B. 20 years.
   C. 30 years.
   D. 40 years.

2. Which of the following sports was not included in this review?
   A. Bicycling
   B. Skiing
   C. Tennis
   D. Gymnastics

3. A mouthguard should be recommended for any athlete participating in a sport in which dental trauma can occur. The establishment of mouthguard programs for all ages, genders, and sports will eliminate the incidence of dental trauma.
   A. Both statements are true.
   B. The first is true; the second is false.
   C. The first is false; the second is true.
   D. Both statements are false.

4. Over the past 30 years there has been an increase in the number of individuals participating in sports. What is the primary reason for this increase?
   A. Tripling of school sports budgets
   B. A dramatic increase in university physical education majors
   C. Affirmative action
   D. Enforcement of Title IX

5. Mouth protection was offered to athletes more than 150 years ago. Today most sports mandate the use of mouthguards.
   A. Both statements are true.
   B. The first is true; the second is false.
   C. The first is false; the second is true.
   D. Both statements are false.

6. Which teeth are injured most frequently?
   A. Maxillary lateral incisors
   B. Mandibular central incisors
   C. Mandibular lateral incisors
   D. Maxillary central incisors

7. The data gathered in this literature review were accumulated by many different methods. These methods include:
   1. Surveys given to selected groups of athletes
   2. Data from hospital emergency rooms
   3. Surveys given to selected groups of coaches
   4. Data from dental clinics
   A. 1 and 3 only
   B. 2 and 3 only
   C. 1, 2, and 4 only
   D. 1, 2, 3, and 4

8. There now is a central data-gathering center for sports-related dental injuries. This makes it easier to make quantitative and qualitative comparisons.
   A. Both statements are true.
   B. The first is true; the second is false.
   C. The first is false; the second is true.
   D. Both statements are false.

9. The orofacial injuries in the studies reviewed included:
   1. Maxillary fractures
   2. Chipped or avulsed teeth
   3. Mandibular fractures
   4. Soft tissue lacerations
   A. 1, 2, and 3 only
   B. 2, 3, and 4 only
   C. 1, 3, and 4 only
   D. 1, 2, 3, and 4

10. Age-specific studies indicate that the orofacial injury rate of which sport surpasses the injury rate of collision sports such as football and ice hockey?
    A. Bicycling
    B. Skiing
    C. Basketball
    D. Rugby

11. Which member of a football team may have the highest risk for sustaining a concussion?
    A. Center
    B. Linebacker
    C. Running back
    D. Quarterback

12. In one study of basketball players who wore mouthguards, there was a significantly lower dental injury rate than among players who wore no protection at all. It also was found that the wearing of mouthguards lowered the incidence of soft tissue injuries and concussions.
    A. Both statements are true.
    B. The first is true; the second is false.
    C. The first is false; the second is true.
    D. Both statements are false.

13. In what year did the NCAA adopt the mandatory mouthguard rule, which, when combined with facemasks, has reduced the dental injury rate in football to almost zero?
    A. 1958
    B. 1962
    C. 1973
    D. 1979

14. In which sports were players more likely to suffer an injury if they were wearing orthodontic appliances?
    A. Baseball, softball, and hockey
    B. Skiing, gymnastics, and volleyball
    C. Wrestling, soccer, and basketball
    D. Football, rugby, and boxing

15. As of 2003, which sports in the U.S. required the use of mouthguards?
    A. Football, boxing, ice and field hockey, lacrosse
    B. Baseball, softball, basketball, wrestling
    C. Rugby, wrestling, volleyball, skiing
    D. Swimming, bicycling, martial arts, soccer