Injury surveillance at the USTA Boys' Tennis Championships: a 6-yr study

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ABSTRACT

HUTCHINSON, M. R., R. F. LAPRADE, Q. M. BURNETT II, R. MOSS, and J. TERPSTRA. Injury surveillance al the USTA Boys' Tennis Championships: a 6-yr study. *Med. Sci. Sports Exerc.*, Vol. 27, No. 6, pp. 826-830, 1995. Injuries that required physical or medical assistance were recorded for participants al the United States Tennis Association National Boys' Tennis Championships from 1986–1988, 1990-1992 (*N* = 1440, 240 athletes per year). Over the 6-yr period, a total of 304 athletes (or 21.1%) sustained new or recurrent injuries that required evaluation by the medical team. New injuries alone numbered 145 (incidence rate of 9.9 per 100 athletes). The analysis of injuries showed a higher rate of lower than upper extremity injuries. When evaluated by anatomic regions, back injuries were most common followed by thigh, shoulder, and ankle injuries, respectively. When evaluated by injury type, strains and sprains were most common (71% of all injuries) with fractures and dislocations being rare (1.3% of all injuries). The lower extremity provided the majority of sprain type injuries with 87.5% of ligament sprains coming from the knee and ankle. Injuries with tennis eponyms (i.e., tennis toe, tennis leg, tennis elbow, and tennis shoulder) were rare (0%-5% of all injuries). It would appear that these young elite athletes arc at significant risk of injury.

INCIDENCE, PREVALENCE, ELITE, TENNIS TOE, TENNIS LEG, TENNIS ELBOW, TENNIS SHOULDER, TENNIS

Many authors have written about tennis injuries, their epidemiology, and treatment (4,9,10,15, 20,21). Others have written about isolated injuries peculiar to tennis; i.e., tennis toe (17), tennis leg (1,7,8), tennis elbow (2,12,18,23,24,25), and tennis shoulder (26). In most studies on elite and elite junior level athletes, isolated regions or specific types of injury are the focus (6,11,25). In contrast, Reece at al. (27) presented the prevalence and etiology of injuries of elite young tennis players at the Australian Institute of Sport, and Winge et al. (30) presented the prevalence and etiology of injuries in Danish Championship tennis. Both groups noted the importance of studying the incidence and prevalence of injuries to identify possible risk factors for injuries.

The United States Tennis Association (USTA) National Boys' Tennis Championships arc competitions of elite, junior, male, tennis athletes in the United States. The tournament is divided into age levels (16-and-under, and 18-and-under) with 120 athletes at each level. This paper presents the incidence, prevalence, and type of injuries of elite athletes at the USTA National Boys' Tennis Championships. One goal was to confirm the injury patterns noted in other studies (27,30). In addition, our purpose was to define injury patterns by anatomic location, injury type, as well as document trends over the years studied. These data could then serve as a baseline for future research to assess the success of specific interventions in reducing injury rates. Finally, due to the relative paucity of literature on injuries with tennis eponyms in this age group, the incidence and prevalence of these injuries (i.e., tennis toe, tennis leg, tennis elbow, and tennis shoulder) were tabulated and analyzed.

MATERIAL AND METHODS

Injury surveillance was performed at the USTA National Boys Tennis Championships from 1986-1988, 1990–1992. All injuries that required physical or medical assistance were recorded. Athletes were evaluated and injuries documented by an athletic trainer and referred to a tournament physician as needed. Each athlete signed a written informed consent prior to participating in the tournament. The court surface was Dynacourt, which is the same surface used at the U.S. Open Tennis Tournament.

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Each injury was classified as either recurrent or new. New injuries were defined as those occurring for the first time at the tournament. Recurrent injuries were defined as all other injuries that required evaluation by medical staff, were chronic in nature, and initially occurred prior to the tournament. Any reinjury, even if it initially occurred at the tournament, was not considered a new injury and was, therefore, not included in the data used to tabulate the incidence of injuries. Incidence was defined as the number of new injuries at the tournament. Prevalence was defined as the number of new and recurrent injuries that required medical evaluation or treatment. Patient age, injury location, injury type, treatment offered, and ability to return to play were also recorded.

The injuries were classified to anatomic regions similar to those described by Reece et al. (27). Their classification was modified to include the hand in upper extremity injuries, the head and neck in trunk or central injuries, and the groin in central injuries. In addition, injuries were classified into nine injury subtypes: strains, sprains, contusions, abrasions, lacerations, fractures, dislocations or subluxations, inflammation, and miscellaneous (bee stings, heat exhaustion, sore throats, splinters, etc.).

Specific injuries with eponyms associated with tennis were also recorded. Tennis shoulder refers to a drooped, internally rotated shoulder that is caused by long-term overhead arm use contributing to generalized laxity of the shoulder capsule and musculature (26). Tennis elbow is the most recognized and most common of the injuries with a tennis eponym. Tennis elbow most often refers to pain of the extensor carpi radialis brevis and the common extensors of the wrist at the level of the lateral epicondyle (2,12,18,23,24,25). Tennis leg is due to partial tearing of the medial gastrocnemius at the musculotendinous junction (1,7,8). Tennis toe occurs as the athlete abruptly stops or changes directions. The longest toe, usually the great toe, jams forward against the toe box of the shoe and may sprain the interphalangeal joint or cause a painful subungual hematoma (17).

Statistical Analysis

When appropriate, statistical analysis was used. The Bonferroni Fix for simultaneous inference was used to compare the incidence and prevalence of lower extremity injuries to that of upper extremity and central injuries. Simultaneous inference was required because all test results were obtained from a common table. Contingency task analyses for independence (chi-square) were also performed.

Simple linear regressions were used to assess trends in the incidence and prevalence of injuries over the years as well as the actual number of athletes sustaining injuries. The year was considered the independent variable. The number of injuries or number of injured athletes was the dependent variable. The importance of the evaluation of trends is twofold. First, if there are no significant changes or trends from year to year, data can be grouped or collapsed into smaller categories without invalidating the data for use in other analyses such as chi-square or the Bonferroni Fix test. Second, if there is no significant change in the proportion of athletes injured from year to year, one can infer information from the results presented about the athletes themselves and not just the number of injuries at a given tournament.

TABLE 1. Incidence and prevalence of injury by region.

Region	Incidence per 100 Athletes	Incidence per 1000 AE	Prevalence per 100 Athletes
Feet	1.1	2.4	2.1
Ankle	0.7	1.5	2.4
Leg/call	0.2	0.5	0.7
Knee	1.9	0.5	1.3
Thigh	1.9	4.1	2.6
Hip	0.8	1.8	1.3
Total Lower	4.9	10.7	10.3
Head/neck	0.7	1.5	0.8
Back	1.2	2.6	3.4
Abdomen	0.3	0.6	0.6
Groin	0.2	0.5	0.4
Total Central	2.4	5.1	5.2
Hand	0.8	1.7	0.9
Wrist	0.2	0.5	0.8
Shoulder	0.9	2	2.5
Elbow/forearm	0.8	1.7	1.4
Total Upper	2.6	5.7	5.6
Total	9.9/100 athletes	21.5/1000 AE	21.1/100 athletes

RESULTS

The 1440 tournament participants were involved in 1812 singles matches and 756 doubles matches for a total of 6648 athletic exposures (AE). A total of 304 injuries were recorded and evaluated by the health care team (injury prevalence = 21.1 per 100 athletes). There were 143 new injuries recorded during the tournaments (tournament injury incidence = 9.9 per 100 athletes, 21.5 per 1000 AE). Twenty-seven athletes had multiple injuries.

Injuries by Anatomic Region

The incidence and prevalence of injuries by anatomical region are shown in Table 1. The most common anatomic site of injury in this series was back, followed by thigh or hamstrings, shoulder, and ankle. The least common injuries were groin and abdomen.

The incidence and prevalence of lower extremity injuries was approximately twice that of upper extremity injuries and the difference was statistically significant ($P = 0.007$, $P < 0.0001$, respectively). The incidence and prevalence of central injuries compared to upper extremity injuries were not statistically different ($P = 0.3181$ and $P = 0.3157$, respectively).

TABLE 2. Incidence and prevalence of injury by type.

Type	Incidence per 100 Athletes	Incidence per 1000 AE	Prevalence per 100 Athletes
Sprains	5.8	12.6	11.6
Strains	1.3	2.7	3.6
Contusions	0.7	1.5	0.8
Abrasions	1	2.3	1.6
Lacerations	0.2	0.5	0.2
Fractures	0	0	0.2
Dislocations	0.1	0.2	0.1
Inflammation	0.1	0.2	2.1
Miscellaneous	0.7	1.5	0.8
Total	9.9/100 athletes	21.5/1000 AE	21.1/100 athletes

Injury Trends Over the Years Studied

No significant change or trend in incidence or prevalence of injuries by anatomical location or region was found by simple linear regression. In addition, no significant change or trend in the number of injured athletes, athletes with new injuries or athletes with old injuries was found.

Injuries by Clinical Type

New and recurrent injuries were categorized into the nine injury subtypes (Table 2). Sprains and strains were most common. The lower extremity provided the majority of the sprain type injuries (87.5%). More sprains, contusions, and abrasions occurred in the lower and upper extremities than what would be expected under independence ($P = 0.0001$). More strains and inflammation occurred in the central region than what was expected under independence ($P = 0.0001$). The incidence of a new strain or sprain was 7.1 per 100 athletes (15.3 per 1000 AE), and the overall prevalence of strains and sprains was 15 per 100 athletes. Fractures, dislocations, and subluxations were rare.

Through the course of the six tournaments studied, six athletes (four in 1987 alone) sustained bee stings. All were treated locally and none had an anaphylactic reaction. In 1988 and 1992, the weather was particularly warm and humid. Seven athletes (2.9 per 100 athletes) required treatment for heat related disorders in 1988. Three had heat-related cramping. Three had early heat exhaustion and one athlete required transportation to the hospital for heat exhaustion. He was the only patient to require such assistance in the 1440 athletes and 6-yr studies. Four additional athletes had symptoms of early heat exhaustion in 1992. There were no cases of heat stroke in all tournaments evaluated. To assess the significance of the incidence of heat-related disorders in 1988 and 1992, Fisher's exact test and the "classic" test for equality of two independent population proportions were used. The number of heat-related disorders in 1988 and 1992 was significantly greater than the numbers of heat related disorders in other years ($P = 0.0002$). The overall incidence of heat related disorders was 0.8 per 100 athletes and 1.7 per 1000 athletic exposures.

Injuries with Associated Tennis Eponyms

Injuries with associated tennis eponyms were rare. Only six athletes had tennis toe (incidence = 0.3 per 100 athletes, prevalence = 0.4 per 100 athletes, and 2% of all injuries). No athlete had tennis leg. Seventeen athletes had tennis elbow with 13 cases being chronic (incidence = 0.3 per 100 athletes, prevalence = 1.1 per 100 athletes, and 5.6% of all injuries). Shoulder injuries were reported in 36 athletes, 13 of which were newly diagnosed (incidence = 0.9 per 100 athletes, prevalence = 2.5 per 100 athletes, and 11.8% of all injuries reported). No athlete, however, had the complete syndrome of "tennis shoulder."

DISCUSSION

Although racquet sports have recently enjoyed an increased interest in the medical literature (4,19,22), many studies of children in sport or high school athletes exclude or only briefly mention tennis injuries (9-11,20,21). Previous reports that have discussed the junior elite tennis athlete have been conflicting especially concerning the relationship between lower and upper extremity injuries and none had supportive statistical analysis.

Incidence and Prevalence

Recce et al. (27) reported 176 injuries at the Australian Institute of Sport over 4 yr and noted 59% involved the lower limb with the others being equally distributed between trunk and upper extremity injuries. In contrast, Winge et al. (30) presented a prospective study of 104 elite athletes and noted 45.7% of the injuries in the upper extremity with only 39% and 11% of injuries in the lower extremity and back, respectively. At the USTA Boys' Championships, lower extremity injuries occurred twice as frequently as upper extremity injuries and the difference was statistically significant. Central injuries had a similar overall incidence and prevalence as upper extremity injuries. Winge et al. (30) also noted an overall prevalence of 30 injuries per 100 athletes in Danish Championship tennis which is consistent with the prevalence of injuries (21 injuries per 100 athletes) in this study.

Tennis Eponyms

After thorough literature review, no article was found that completely evaluated the incidence and prevalence of tennis toe, tennis leg, or tennis shoulder in elite junior athletes. Leach and Lewis (17) noted that tennis toe occurs most frequently in runners, but no report documents the incidence and prevalence of tennis toe in a young elite population. In the athletes at the USTA Boys' Championships, the injury was rare occurring in only 0.4 per 100 athletes. Perhaps, although not documented in

this study, tennis toe would be more prevalent in the novice player because proper technique and quality footwear are viewed as preventive factors.

Arner and Lindholm (1), Froimson (7), and Garrick (8) have discussed tennis leg as a partial tear of the medial gastrocnemius at its musculotendinous junction and noted that although it primarily occurs in middle age tennis players, it can occur in the young tennis player or even the nontennis athlete. The aforementioned provide no incidence and prevalence of the injury. None of the 1440 athletes at the USTA Boys' Championships sustained such an injury.

Priest and Nagel (26) described a deformity about the shoulder of tennis athletes involving shoulder droop and internal rotation that caused pain when specific strokes, particularly the serve and overhead, were attempted. They noted that 50% of athletes had shoulder pain at some time during their playing career. Priest and Nagel (26) hypothesized that the scapular elevators had been stretched secondary to overuse. Thirty-six athletes at the USTA Boys' Championships had complaints of shoulder pain (prevalence = 2.5 per 100 athletes). Although this might be a prodrome to developing "tennis shoulder," none of the athletes was noted to have a significantly drooping or internally rotated shoulder.

Of all injuries with tennis eponyms, tennis elbow has been the most widely studied (2,12,18,23-25,28). Carroll (2) noted that 34% of local league players suffered from tennis elbow. Nirschl (23) noted a 35% incidence of tennis elbow in world class tennis athletes. Priest (24) and Priest et al. (25) noted a 45% incidence of tennis elbow in world class tennis athletes with 37% being severe. Winge et al. (30), however, reported 10% of the injuries in the Danish elite tennis athletes were tennis elbow. Only 5.6% of all injuries reported in the USTA Boys' Championships were tennis elbow. The tournament incidence rate was 0.3 per 100 athletes (prevalence = 1.2 per 100 athletes). The difference between the reports of world class athletes and those from the Danish and the USTA Boys' Tennis Championships may be due to the relative youth of the athletes in the latter two series. This would support Gruchow's opinion (12) that tennis elbow is related to age and frequency of play. The incidence may also vary with technique and equipment (5).

Overuse Injuries

Both the studies by Reece et al. (27) and Winge et al. (30) noted a predominance of overuse type of injuries. In the athletes studied at the USTA Boys' Tennis Championships, strains and sprains were also the most common type of injury. Laness et al. (16) found that sprains and strains made up 50% of injuries in matched men's and women's intercollegiate sports. Kibler et al. (14) found that the majority of tennis injuries are of the overload variety. In young athletes the volume of training is related to the incidence of injury and should be monitored carefully. Preparticipation stretching may also reduce sprains and strains (15,29). Although good scientific data is unavailable to confirm this hypothesis, it is intuitive that by emphasizing and encouraging appropriate preparticipation stretching regimens of areas at risk that a reduction in the incidence of overuse injuries in these young tennis athletes might be achieved.

More specifically, overuse appears to be a primary factor associated with low back strains and sprains in elite tennis athletes. At the USTA Boys' Championships back injuries were surprisingly common (16.1% of all injuries). Kuland et al. (15) emphasized the need for an aggressive warm-up and stretching routine including the spine to prevent overuse injuries. Leach and Lewis (17) associated low back strain with service technique, especially the American Twist, which demands a marked increase in the amount of lumbar lordosis. Chandler et al. (3) found that elite junior tennis athletes tend to have reduced flexibility in their low spine which they believed was consistent with the common complaint of low back pain in junior tennis athletes. Chi-square analysis of the results of the USTA Boys' Championships showed that strains and inflammation were significantly more common in the central region than either the lower or upper extremities. A thorough preparticipation stretching and abdominal strengthening regimen may, in theory, reduce the incidence of low back pain in the young tennis athlete. Indeed, the extremities might also benefit from such a regimen.

Chandler et al. (3) reported decreased flexibility to internal rotation of the shoulder in junior elite tennis athletes. They suggested that a preparticipation stretching regimen for the shoulder might also be beneficial in reducing the incidence of shoulder injuries. Jobe (13) and Richardson (28) have emphasized the importance of isolated rotator cuff strengthening to reduce and prevent shoulder girdle problems and rotator cuff pain.

Other Injuries

Injuries at the USTA Boys' Championships were not limited to the musculoskeletal system. The incidence of bee stings at the USTA Boys' Tennis Championships was probably associated with the time of year, the region of country, as well as the close proximity of flower gardens and trash cans. The incidence of heat-related disorders was noted to be related to the weather. These heat related disorders were of special concern as they were the only truly life-threatening injuries cared for throughout the tournaments studied and accounted for the single episode that required emergency transport. Although not common, these injuries do serve to emphasize that being

prepared for all possible scenarios when caring for athletes is necessary.

CONCLUSION

This study presents the incidence and prevalence of injuries in a young elite group of tennis athletes. Because the population was closely defined, the injury rates and risks cannot be generalizable to larger or different populations of athletes. The study does serve, however, as an excellent baseline of comparison for future studies on the young elite male tennis athlete.

From this study we therefore conclude:

1) Lower extremity injuries are twice as frequent as upper extremity or central injuries in the young elite tennis athlete.

2) Central injuries especially those of the spine are surprisingly common and similar in frequency as upper extremity injuries in this age group. Central injuries have a greater incidence of strains and inflammation than upper or lower extremity injuries.

3) Tennis elbow is less frequent in the young elite tennis athlete in comparison to the older population.

4) Other injuries with associated tennis eponyms, i.e., tennis toe, tennis shoulder, and tennis leg, are rare in the young elite tennis athlete.

5) Overuse injuries, especially sprains and strains, are the most common type of injury in the young elite tennis athlete.

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