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Purpose.—This section provides current information related to the medical needs of young athletes, as pertinent to counseling young athletes and their parents regarding sports participation and practices contributing to the health maintenance of the athlete, as well as current concepts in the prevention, diagnosis, and treatment of sports-related illnesses and injuries.

Editorial Comment.—Little information is available in the pediatric literature concerning the areas of weight training, power lifting, and bodybuilding. With the emphasis currently being placed on strength training for virtually all sports, it is important for the pediatrician to recognize the benefits and problems related to this activity. Injuries related to strength training are reported in this article that reviews, retrospectively, a sample of junior high school and high school football players. This should provide a stimulus for additional well-designed prospective studies to define the issue more thoroughly. A greater awareness of the problems usually results in reasonable solutions.—W.B.S.

Weight-Training Injuries in Adolescents

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- We studied the incidence of injury caused by weight training in junior and senior high school football players. Three hundred fifty-four subjects completed a retrospective injury questionnaire; histories were confirmed for high school athletes. Cumulative incidence and incidence rates were determined for injuries causing more than 7 days of missed participation. The cumulative incidences of injuries were as follows: all athletes, 7.8% (27/354); junior high school athletes, 7.1% (7/98); high school freshman/junior varsity athletes, 9.4% (15/159); and high school varsity athletes, 5.2% (5/97). The total incidence rate was 0.082 injuries per person-year, with 0.11 injuries per person-year in junior high school athletes, 0.091 injuries per person-year in high school freshman/junior varsity players, and 0.051 injuries per person-year in high school varsity players. Differences in the incidence measures among groups were not statistically significant. The most common injury type was a strain (74.1%), and the most common site was the back (58.3%). Certain exercises apparently caused more back injuries in older athletes.

Prevention of injury is a major goal of the primary care physician. This requires knowledge of the incidence and causes of injury in a given activity. These data are not available for musculoskeletal injuries caused by weight training, which is now widely used as a conditioning method by secondary school athletes. Available injury data concern only selected populations as follows: adolescents referred to orthopedists and members of a team that lifts weights competitively in the sport of power lifting. In addition to better information concerning injury rates, a better understanding is needed of the specific risk factors for injury.

The purpose of this historical cohort study was to establish the incidence of significant injuries (disability, >8 days) caused by weight training when this activity was part of the conditioning program for secondary school athletes who played football. Information on training programs was obtained, with the hope that risk factors for injury could be identified.

**SUBJECTS AND METHODS**

The subjects were interscholastic football players from four high schools competing in the division containing the largest Texas public schools (6A) and junior high school athletes from the same school district. The junior high school athletes were encouraged to train with weights but did not have school-based programs; they therefore varied considerably in their training activities, although almost all used free weights in four major lifts: the bench press, the overhead press, the squat lift, and the incline press (Table 1). The high school athletes at each school were required to participate in a carefully organized weight-training program supervised by the coaching staff. Each school's weight-training program was based on three major lifts: the bench press, the power clean, and the squat lift (three schools) and the bench press, the clean and jerk, and the clean lift (one school). These exercises were performed with three to four sets of 6 to 12 repetitions. Two schools also emphasized the overhead press, and three emphasized the incline press. Two or three assisting exercises with dumbbells and leg machines were also used at each school. The athletes trained most aggressively during the winter and spring after the end of the football season, but also continued their program through the summer and fall.

During preparticipation physical examinations in August 1986, each athlete completed a written questionnaire about his training program and about the type, location, and severity of musculoskeletal injuries caused by weight training during his year(s) on the team that he had played for most recently; junior high, high school freshman/junior varsity (treated as one team in this study), or high school varsity. The questionnaire was reviewed with each athlete for accuracy and completeness. Current injuries and disability from
old injuries caused by weight training were evaluated by the high school athletic trainers and physicians during the physical examination. The athletic trainers verified the injury histories for the high school football players; they were required to see the trainer when injured, except during the summer.

Inadequate coaching, weight training at home without adult supervision, and use of free weights without spotters have been proposed as factors that increase injury risk, as has lack of experience. We therefore acquired information on these factors, with the hope of identifying the causes of at least some injuries. In characterizing the athletes' training programs (Table 1), the following definitions were used. The athletes were "taught by a coach" if that individual instructed them on the proper technique for each of their exercises at the beginning of their weight-training program. Otherwise, they were taught by a friend, a parent, or trial and error. They "trained at school" if their conditioning program took place in the school weight room both during the school year and the summer; if not, they trained at home or at a public gymnasium. They were "supervised" if a coach was present during the school year and if one or two spotters were always present when they performed a major lift (Table 1) with the use of free weights.

Table 1 also reports the percentage of athletes performing the major lifts. These exercises can cause significant injuries and, therefore, were also of interest in our efforts to identify reasons for injury. As mentioned above, in the high schools, several of the major lifts were considered to be the most important part of the program, and the junior high school athletes also used one or more of these exercises.

The National Athlete Injury/Illness Reporting System classification was used to categorize the injuries. Significant injuries were those that caused at least 8 days of missed participation. They were further classified as moderate (8 to 21 days of disability), major (>21 days), or severe (permanent disability).

Two measures of injury incidence were determined. The cumulative incidence, which is a measure of individual risk for injury, was calculated by dividing the number of injuries by the total number of athletes at risk; it is reported as the percentage of athletes injured. Since injury histories of the junior high school athletes could not be confirmed, the cumulative injury incidence for this group may have been approximate. The second incidence measure, the incidence rate, was calculated by dividing the total number of injuries by the athletes' total person-years of lifting experience; it was reported as injuries per person-year. Possible inaccuracies in the number of injuries in the junior high school subjects may have affected this measure for this group.

Ninety-five percent confidence intervals for the cumulative incidence were obtained by using the exact binomial method for the subgroups or the normal approximation for the total incidence. The χ² test was used to determine if the cumulative incidence of injury differed significantly among the three groups (P = .05). Ninety-five percent confidence intervals for the injury rates were determined by using the normal distribution approximation. To compare injury rates, the ratios between pairs of rates were calculated as a measure of relative risk. Ninety-five percent confidence intervals on these ratios were obtained by using the test-based method. If the confidence interval included 1 (no difference in risk), the differences between rates were not significant (P = .05).

This research was approved by the Committee for the Protection of Human Subjects of the University of Texas Medical School, Houston. Informed consent was obtained from the subjects and one of their parents if the subjects were younger than 18.

**RESULTS**

Information on the athletes' training programs is given in Table 1. Race was as follows: white, 84.4%; black, 5.1%; and Hispanic, 10.5%. The subjects included 61% of the high school varsity players, 58% of the high school freshman/junior varsity players, and 54% of the junior high school players in the school district.

The athletic trainers confirmed the accuracy of the self-reports of duration and type of injury for all but one of the high school athletes; this individual was injured during the summer. The trainers knew of no significant injuries in the athletes who reported none.

Person-years of weight-training experience were as follows: junior high school subjects, 63.6; high school freshman/junior varsity students, 165; and high school varsity students, 98.0. The injury rates with 95% confidence intervals are given in Table 2. Injury rates did not differ significantly among groups.

The confidence intervals for all subgroups for both incidence measures were wide, indicating low precision (Table 2). This resulted from the relatively small number of injuries and of persons and person-years in these subgroups. The total incidence measures were more precise (Table 2).

Injury types included 20 strains, 3 sprains, 2 fractures, 1 tendinitis, and 1 nerve injury. The injured areas were as follows: lower part of the back, 13; upper part of the back, 3; shoulder, 3; hand, 2; knee, 2; neck, 1; upper extremity, 1; wrist, 1; and ankle, 1. The sprains and strains were grade 2 (incomplete tear of a ligament or muscle-tendon unit) or less. The 2 fractures were of a distal radial and ulnar epiphysis and of
Table 2. Injury Incidence Measures With Confidence Intervals

<table>
<thead>
<tr>
<th></th>
<th>Junior High School Athletes (n = 98)</th>
<th>High School Freshman/Junior Athletes (n = 159)</th>
<th>High School Varsity Athletes (n = 97)</th>
<th>All Athletes (N = 354)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative incidence</td>
<td>7.1</td>
<td>(3.6, 11.2)</td>
<td>5.2</td>
<td>(4.2, 6.3)</td>
</tr>
<tr>
<td>(95% confidence interval)</td>
<td>8.4</td>
<td>(5.3, 11.5)</td>
<td>5.2</td>
<td>(4.2, 6.3)</td>
</tr>
<tr>
<td>Injury incidence rate</td>
<td>0.11</td>
<td>(0.095, 0.12)</td>
<td>0.081</td>
<td>(0.070, 0.092)</td>
</tr>
<tr>
<td>(95% confidence interval)</td>
<td>(0.026, 0.19)</td>
<td>(0.045, 0.14)</td>
<td>(0.026)</td>
<td>(0.051, 0.11)</td>
</tr>
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*Units are injuries per person-year.

agree that the major lifts using free weights allow the development of coordinated strength and power in multiple muscle groups more effectively than do weight machines. If athletes use proper technique under good supervision, they can probably decrease injuries caused by the major lifts; proper coaching is not readily available in the secondary school setting.

This retrospective study gave preliminary data on the incidence and causes of musculoskeletal injuries in secondary school football players who train with weights. Prospective research is needed to provide more accurate injury risks and more specific data concerning the causes of injury. Injury incidence depends on the quality, content, and intensity of the training program. Thus, evaluations of football players in other schools, and athletes playing other sports, will give a more complete picture of the risks of this activity.

References

9. Alles WE, Powell JW, Buckley W, Hunt EE, The National Athlete Injury Illness Reporting System classification of severity of injury was not used, this latter group of athletes apparently had a greater number of significant injuries. Seventy-one subjects with a mean duration of lifting experience of 17.1 months had 96 injuries that resulted in 1126 days of missed participation.

Possible inaccuracies in the injury incidence for the three groups were discussed above. As another possible source of bias, we studied only a subgroup of the football players in the district. How this incomplete sample affected our results is unknown. An additional possible source of error resulted from using the number of days of missed participation as the definition of injury. This is affected by the athletes' desire to play and tolerance for pain, by the judgment of the athletic trainers and team physicians, which may vary from case to case, and by the position played (a lineman may play with an injured finger, while a quarterback may not).

The information on the training programs gave an interesting descriptive picture. Teaching and supervision increased with the level of participation, while the injury rate decreased. The training of high school athletes made aggressive use of the major lifts. We could make few conclusive statements about risk factors for injury. The junior high school athletes, with the highest injury rate and the only fractures, were apparently less well taught and supervised but also had lifted for fewer months and used fewer of the major lifts than the high school athletes (Table 1). The subject with the fracture of the radius and ulna sustained this during an overhead press; this exercise has been previously recognized as a cause of this injury and may not be appropriate for adolescent athletes. This may be particularly true at the time of the adolescent's peak velocity of height growth, when fractures of the distal forearm apparently have their greatest incidence. All of the athletes who injured their backs were performing one or more of the following lifts: the power clean, the clean and jerk, the squat lift, or the dead lift. Greater use of these exercises was a plausible explanation for the greater proportion of back injuries in the junior school (60.0% of injuries) compared with the junior high school athletes (14.3%). Although no data are available to confirm this hypothesis, it is possible that the use of weight machines rather than free weights may decrease the incidence of back injuries. However, weight-training coaches generally