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Catastrophic Injuries in Pole Vaulters

A Prospective 9-Year Follow-up Study

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Background: A prior review of catastrophic pole vaulting injuries from 1982 through 1998 revealed an average of 2.0 injuries per year, with 69% (1.38 per year) of the injuries secondary to athletes landing off the sides or back of the landing pad and 25% (0.5 per year) from athletes landing in the vault box. In 2003, several rule changes for the sport of pole vaulting were mandated, including enlarging the minimum dimensions of the landing pad.

Hypothesis/Purpose: Our goals were to (1) identify the post-2003 rule change incidence and profile of catastrophic pole vaulting injuries through 2011 and compare them, where possible, with the prior incidence and profile and (2) determine, via a questionnaire, the frequency with which pole vaulters land in the vault box. We hypothesized that the new, larger landing pads would reduce the number of catastrophic injuries.

Study Design: Descriptive epidemiology study.

Methods: We prospectively reviewed all catastrophic pole vaulting injuries (ie, brain hemorrhage; skull, spine, or pelvic fracture; substantial pulmonary or intra-abdominal injury) in the United States from 2003 through 2011, surveyed 3335 pole vaulters to determine the frequency of landing in the vault box, and compared results with those in the literature.

Results: From 2003 to 2011, 19 catastrophic injuries occurred (average of 2.1 per year), with the majority (n = 14, 74%, 1.55 per year) landing in or around the vault box. Four (21%, 0.44 per year) injuries occurred when an athlete landed off the sides or back of the landing pad and 1 (5%) when the pole broke. There were 11 (58%) major head injuries (1 fatality), 4 (21%) spine fractures (1 with paraplegia), 2 (11%) pelvic fractures (both with intra-abdominal injuries), 1 (5%) brain stem injury (fatal), and 1 (5%) thoracic injury (rib fractures and pneumothorax). The annual fatality rate fell from 1.0 in the prior study to 0.22 in the current study. According to the pole vaulters survey, during their careers, 77.12% (n = 2572) landed in the vault box 1 to 3 times, 15.92% (n = 531) never landed in the vault box, 6.12% (n = 204) landed in the vault box 4 to 6 times, and 0.84% (n = 28) landed in the vault box 7 or more times.

Conclusion: The 2003 rule changes have markedly reduced the number of catastrophic injuries, especially fatalities, from pole vaulters missing the back or sides of the landing pads; however, the average annual rate of catastrophic injuries from pole vaulters landing in the vault box has more than tripled over the past decade and remains a major problem.

Keywords: pole vaulting; catastrophic injuries; mechanism; prevention

Pole vaulting is associated, by a large margin, with the highest risk of direct catastrophic injuries in track and field, and before 2003, it had one of the highest rates of direct, noncardiac catastrophic injuries per 100,000 participants for all sports monitored by the National Center for Catastrophic Sports Injury Research (NCCSIR).[7] Although literature on pole vaulting injuries is sparse, 1 study documented 32 catastrophic injuries over a 16-year span (1982-1998 academic years), 30 (94%) of which involved the landing pad (n = 22, 69%) or vault box (n = 8, 25%), and all of which resulted in serious head injury (n = 31, 97%) or spine fracture/paraplegia (n = 1, 3%).[2] Of the 31 athletes who sustained a head injury, 16 (52%) died, and 6 (19%) had incomplete neurological recovery (19%).

This information, plus the 6 catastrophic pole vaulting injuries resulting in 3 fatalities recorded in 2002, prompted the National Collegiate Athletic Association (NCAA), the National Federation of State High Schools Associations (NFHS), and USA Track and Field (USATF) to mandate rule changes to promote safety in the sport of pole

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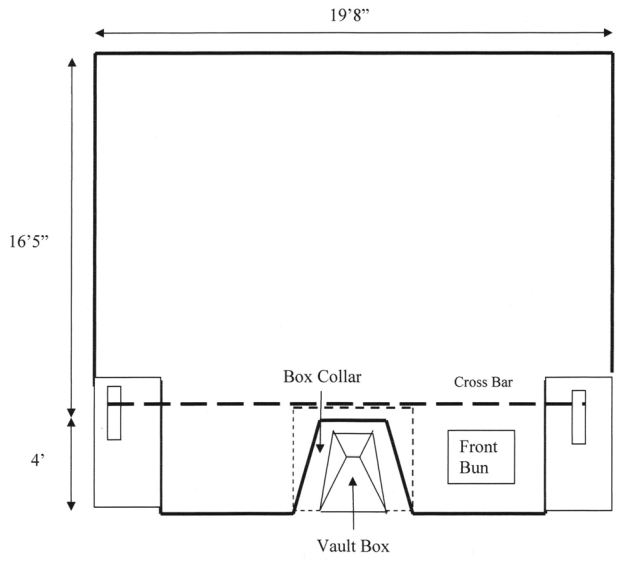

Figure 1. Minimum dimensions of the landing pad according to the National Collegiate Athletic Association and National Federation of State High Schools Associations 2003 rule change.

vaulting.[3,8] It was believed that the rule change with the most potential to reduce injuries was the increase in the minimum dimensions of the landing pad behind the vault box from 16 ft × 12 ft to 19 ft 8 inches × 16 ft 5 inches (Figure 1). The NFHS also mandated that all hard surfaces surrounding the sides and back of the landing pads be removed or padded with a minimum of 2 inches of dense foam or other suitable material(s) and that any excess material (eg, asphalt or concrete) extending from beneath the landing pad be removed.[3] The NCAA did not mandate any regulations concerning the surfaces surrounding the sides and back of the landing pad, but both organizations mandated a minimum of 2 inches of dense foam or other suitable material in the box collar (space between the vault box and landing pads). The NCAA and NFHS also mandated that the crossbar be a minimum of 17.7 and 15.7 inches, respectively, beyond the vertical plane of the back of the planting box to encourage vaulters to land closer to the center of the landing pads. In 2003, the NFHS allowed the runway to be marked so athletes could better gauge the takeoff and recommended a preferred landing zone be painted or sewn in the middle of the landing pad to encourage central landing. In 2003, the NCAA prohibited coaches from pushing (tapping) the vaulters during warm-ups and competition. In 2004, the NCAA allowed the runway to be permanently marked in the take-off area.[9]

The goals of this study were to (1) identify the post-2003 rule change incidence and profile of catastrophic pole vaulting injuries through 2011 and compare them, where possible, with the pre-2003 incidence and profile and (2) determine, via a questionnaire, the frequency with which pole vaulters land in the vault box. Specifically, we hypothesized that the new, larger landing pads would reduce the number of catastrophic injuries.

MATERIALS AND METHODS

Injury Definitions

For the 2003 through 2011 calendar years, we prospectively collected data on catastrophic pole vaulting injuries in the United States. Direct catastrophic injuries were defined as any severe injury, for example, a brain hemorrhage or skull fracture, spine or pelvic fracture, or substantial pulmonary or intra-abdominal injury, resulting from participation in pole vaulting. Indirect injuries resulting from systemic failure because of exertion were not included. Concussions and extremity injuries were not considered catastrophic injuries.

Injury Reports

Data were collected from the NCCSIR, Internet searches (Google, polevaultpower), and communication with the National Pole Vault Safety Committee and the Pole Vault Safety Certification Board.[5] The NCCSIR annually contacts the following sources, requesting reports on catastrophic injuries: high school and college coaches and athletic directors, executive offices of state and national athletic organizations, athletic trainers, and a national newspaper clipping service. The Pole Vault Safety Certification Board also documents catastrophic injuries and meets annually with the American Society for Testing and Materials to discuss equipment, rule changes, injuries, and safety measures for pole vaulting.

Injury Surveillance

Injuries identified through the NCCSIR, the National Pole Vault Safety Committee, the Pole Vault Safety Certification Board, and the Internet searches were recorded, and additional detailed information was obtained through contact with the athlete, family member, coach, and/or witness, through Internet searches and Facebook, and/or via Internet videos of the injuries. A detailed questionnaire was used to collect data on patient characteristics (age, gender), date of injury, level (high school, college, other), and highest jump previously attained. Information concerning the mechanism of injury (missed landing pads completely or incompletely, vault box, other) was elicited with specific attention to whether the equipment was in compliance with the 2003 rule changes. Additional information was obtained on whether the injury occurred during practice or competition, the height attempting to jump at the time of injury, whether the athlete was wearing a helmet, weather conditions, and equipment used. Information was also elicited concerning the medical diagnosis, treatment, outcome, prevention, and whether there was litigation.

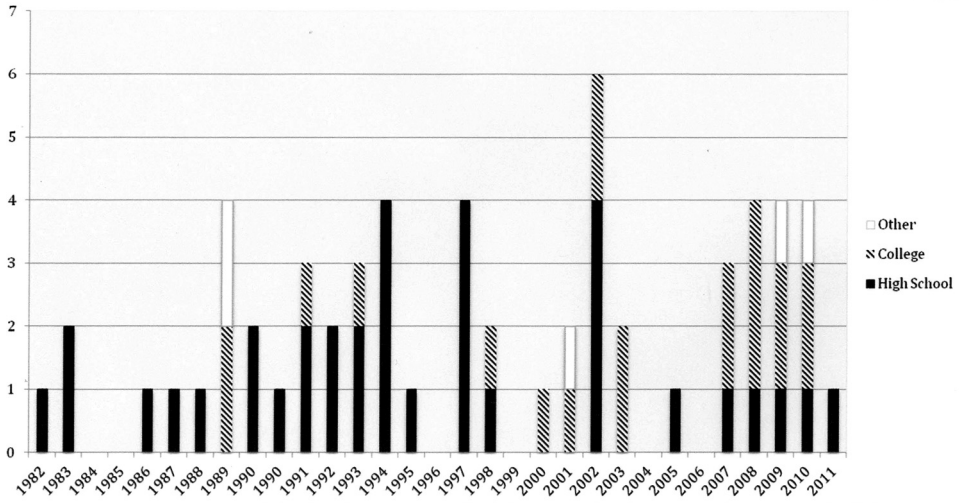

Figure 2. Number of catastrophic injuries per year in pole vaulting from 1982 through 2011.

Participation Numbers

Although the NFHS and NCAA record the number of track and field participants each year, they do not record the number of pole vaulters within the sport of track and field. We estimated the total number of high school pole vaulters in the 2008 and 2010 years to be 80,000.[11] This number was estimated by determining the exact number of pole vaulters in the states of Washington and Oregon and then calculating the number of pole vaulters per total track and field athletes in these states. This ratio was then multiplied by the total number of high school track and field athletes in the United States, excluding the states that do not offer pole vaulting, to determine the total number of pole vaulters in the United States at the high school level. Because only athletes who competed in track meets and not those who may have practiced with the teams without competing were included, we estimated that the total number of pole vaulters at the high school level each year was 90,000 (50,000 male vaulters and 40,000 female vaulters). At the college level, the Web site athletic.net recorded the results of 99% of all collegiate track meets in 2010. During the outdoor season, 2171 men and 1446 women were recorded as having cleared a bar. These numbers do not include competitors who did not clear a height or athletes who practiced but did not compete. A brief survey of 18 college coaches indicated an average of 1 noncompetitor for every 5 competing men and 1 for every 6 competing women. Therefore, the estimated number of college participants was 4300 (2600 men and 1700 women).

Survey

A survey was administered to all participants at all pole vault camps and clinics provided by one of the authors from 2007 through 2011. The purpose of the survey was to determine the profile and frequency of athletes landing in the vault box. All participants were queried on age, gender, number of seasons participating in the sport of pole vaulting, personal best vault attained, and frequency of landing in the vault box. Participants who had landed in the vault box were asked whether the injury required medical attention, and if so, what portion of their body they injured.

RESULTS

A total of 19 direct, catastrophic pole vaulting injuries were identified from 2003 through 2011 (Figure 2). Of the 18 contacts who were located for completion of the detailed questionnaire, information was obtained via telephone call or e-mail correspondence with the athlete in 10, the coach in 4, a parent in 3, and a teammate who witnessed the injury in 1. Information from Internet articles only was obtained for the 19th athlete, but a parent was interviewed in the article. A videotape of the injury was reviewed for 2 athletes contacted.

Epidemiology and Demographic Patterns

Sixteen injuries occurred in male vaulters and 3 injuries in female vaulters. There were 11 (58%) college, 6 (32%) high school, 1 (5%) middle school, and 1 (5%) professional vaulters (Figure 2). The mean age at injury was 19 years (range, 14-26 years). The mean highest successful vault was 13 ft 4 inches (range, 9 ft to 19 ft 8 inches), and the average overall annual rate of injuries was 2.1 (1.78 for male vaulters and 0.33 for female vaulters).

Based on our estimated participant numbers, the average annual incidence of direct catastrophic injuries at the combined high school and college levels for the 9-year period was 2.0 per 100,000 pole vaulters (3.0 per 100,000 male vaulters and 0.8 per 100,000 female vaulters). The

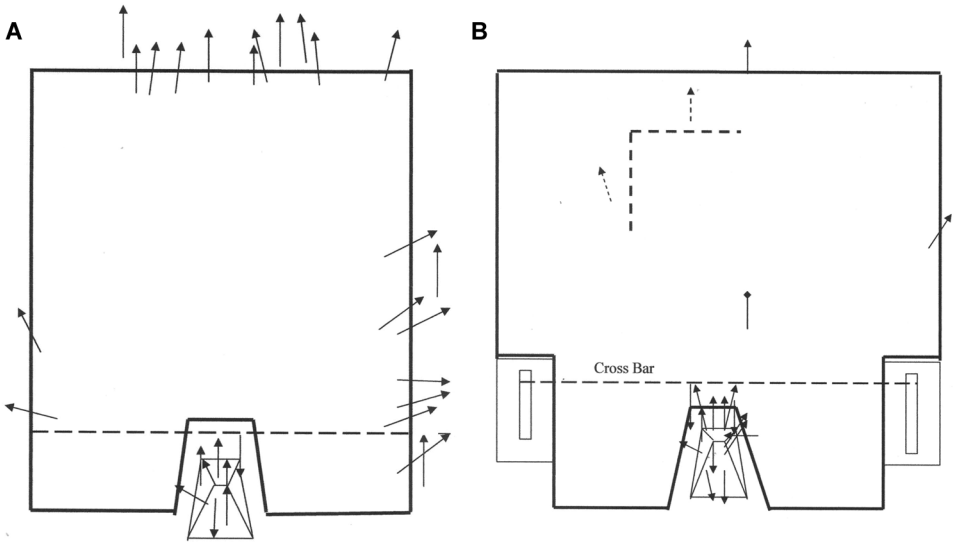

Figure 3. Location of landing for athletes in the 1982 to 1998 (A) and 2003 to 2011 (B) studies of catastrophic pole vaulting injuries. Arrowheads represent the head of the pole vaulter, and the tails of the arrows represent the torso and feet of the pole vaulter. (B) The dotted lines and arrows represent the 2 circumstances where the schools were in noncompliance with the dimensions of the 2003 minimum landing pad rule.

total incidence during the 9-year period was 28.4 per 100,000 (38.5 per 100,000 men and 13.1 per 100,000 women) for college pole vaulters and 0.07 per 100,000 (1.1 per 100,000 male vaulters and 0.3 per 100,000 female vaulters) for high school pole vaulters.

Injury Timing and Conditions

Of the 19 accidents, 8 occurred during a competition, 6 during practice, 4 during precompetition warm-up, and 1 unknown. In 11 incidents, the average height attempted was 13 ft 4 inches (range, 9 ft to 18 ft 6 inches). The remaining injuries occurred in practice without a bar (n = 4) or the height was unknown (n = 4). None of the athletes was wearing a helmet at the time of the injury. Weather conditions were not considered to be a causative factor in any of the injuries.

Injury Profile

There were 11 (58%) major head injuries, 4 (21%) spinal column fractures (1 with paraplegia), 2 (11%) pelvic fractures, 1 (5%) brain stem injury, and 1 pneumothorax with rib fractures (5%). Of the 11 major head injuries, concomitant injuries included a skull fracture in 6 athletes, a C7 transverse process fracture and a lumbar disc herniation in 1 case, and a clavicle fracture and temporary quadriparesis in 1 athlete. One of the athletes who sustained a pelvic fracture also was diagnosed with a pneumothorax, splenic rupture, and a rib and clavicle fractures. The other pelvic fracture injury was associated with an intra-abdominal bleed and a hip fracture.

Nine athletes required 1 or more surgical procedure(s): 6 required cranial decompressions, 2 required a spinal procedure, and 1 required a splenectomy and clavicle open reduction with internal fixation. Five athletes did not require surgery, and the need for surgery was unknown in 5 athletes.

Mechanisms

The most common mechanism of injury (n = 14, 74%) was premature pole release or lack of momentum, resulting in landing in the vault or planting box and/or box collar (Figure 3). There was padding in the box collar around the vault box in 4 cases, no padding in 3 cases, and unknown in 7 cases. Circumstances and landing patterns for the vault box injuries varied. Many vaulters reported landing with part of their body on the landing pads or front buns and their head in the vault box or vice versa. Several landed completely in the vault box or on an asphalt or metal box edge or on the runway surface material in the space between the vault box and the landing pads. One athlete's pole tip caught on the front lip of the vault box, which was warped and above the surface of the runway, disrupting the pole's planting position. Other risk factors for landing in the vault box were changing to a stiffer pole or higher grip before the jump in an attempt to clear a higher bar. Often, the pole vaulter waited too long to raise his or her arms to plant the pole, had a poor approach run, or did not have enough speed and/or power to allow the stiffer pole to carry him/her onto the landing pad. Several pole vaulters reported that their hands slipped off the pole before completing the jump.

The second most common mechanism (n = 4, 21%) occurred when athletes landed on a hard surrounding

surface to the sides or back of the landing pad (Figure 3). All 4 instances occurred at the college level, and in all 4, there was no supplemental padding around the landing pads. Two athletes struck their heads on concrete, 1 on a rubberized track surface, and 1 on a rubberized gym floor. In 2 cases, the facilities did not comply with the 2003 rules: in 1, a landing pad did not meet the minimum size requirements; in the other, multiple high-jump pads were used as a pole vault landing pad, which lacked a uniform surface and the minimal pole vault landing pad dimensions.

During an attempt to vault 14 ft, 1 college athlete sustained a skull fracture and severe head injury with seizures when the pole broke and hit him in the head, although he landed in the middle of the landing pad. The pole met regulation standards and had no known defects.

Outcomes

During the 9-year span, 2 athletes (11%, 0.22 per year) died. One athlete landed on the side of the landing pad, and 1 landed in the vault box, resulting in trauma to the head and trauma to the brain stem, respectively. Both athletes died within 36 hours of the injury.

The recovery for the 17 athletes who survived was complete for 10 and partial for 7. Of the 10 athletes with full recovery, 3 decided not to return to pole vaulting because of fear of reinjury, and 7 returned to competition in pole vaulting, but 2 eventually quit because of psychological scars from the catastrophic injury. The 7 with permanent disabilities had cognitive impairment (n = 4); paraplegia (n = 1); back pain, paresthesia, and depression (n = 1); and headaches and vertigo (n = 1). In addition to the devastating health and emotional effects, at least 6 of the accidents resulted in lawsuits.

Vault Box Survey

The age of the 3335 vault box survey participants (1844 [55.29%] male vaulters and 1491 [44.71%] female vaulters) ranged from 12 to 18 years, but 85% were 15 to 17 years old (mean, 15.63 years). The mean number of participating seasons was 2.15 (range, 1-6); less than 10% had more than 3 seasons. The mean personal best height vaulted (unknown for 7 participants) was 10 ft 1 inch (range, 6-15 ft).

During their careers, 77.12% (n = 2572) landed in the vault box 1 to 3 times, 15.92% (n = 531) never landed in the vault box, 6.12% (n = 204) landed in the vault box 4 to 6 times, and 0.84% (n = 28) landed in the vault box 7 or more times. Of the 2804 participants who landed in the vault box at least once, only 3.03% (n = 101) required medical attention. There were 130 injured body parts, most frequently the ankle (n = 32, 24.62%), heel (n = 25, 19.23%), lower back (n = 16, 12.31%), and knee (n = 11, 8.46%).

DISCUSSION

According to the NCCSIR, pole vaulting ranks as one of the most dangerous sporting activities,[7] and 1 report analyzing the United States National Registry of Sudden Death in Young Athletes for 30 years (1980-2009) found pole vaulting was second only to football in the number of direct traumatic fatalities.[12] In an effort to reduce injuries in pole vaulting, the NCAA and NFHS instituted several rule changes in 2003,[3,8] most important of which we believe was increasing the minimum landing pad size to 19 ft 8 inches × 16 ft 5 inches.

However, there is little information on pole vaulting injuries in the literature[4,10,13] and, to our knowledge, only 1 study of associated catastrophic injuries.[2] The current study was undertaken to analyze the effect of the 2003 rule changes on pole vaulting's catastrophic injury profile and rate. To do so, we compared our findings with those in the literature and other sources.

In terms of annual injury and fatality rates, the study by Boden et al[2] counted 32 catastrophic pole vaulting injuries between 1982 and 1998, for an annual rate of 2.0, with 16 fatalities. Our current results showing 19 catastrophic injuries (annual rate, 2.1) and 2 fatalities have shown that although the post-2003 annual rate did not change noticeably, the annual rate of fatalities fell dramatically from 1.0 to 0.22. This reduction in fatalities may be secondary to our current findings that more landings occurred in the vault box and less off the sides and back of the landing pads than reported previously.[2] Alternatively, because of the lower number of injuries in this report identified by the NCCSIR and the higher number located through Internet searches and other avenues, it is possible that the new report has more injuries that were "less catastrophic." If more advanced Internet searches had been possible at the time of publication of the prior study, it is likely that a larger number of nonfatal catastrophic injuries would have been identified than were reported in that study.

A comparison of the types of injuries showed severe head injuries were the most frequent injury both before and after 2003, although the percentage markedly decreased in the current study: 31 severe head injuries of the original 32 catastrophic injuries (96.9%), 6 with permanent cognitive disabilities,[2] and 11 severe head injuries of the 19 (58%) catastrophic injuries in the current report, 4 with permanent cognitive disabilities. Therefore, the use of helmets by pole vaulters would seem warranted. However, a fall from a typical pole vaulting height of 3 m or higher onto a hard surface would easily exceed the protection capabilities of a helmet.[1]

Comparison of pre- and post-2003 data shows that the mechanism of injury changed (Figure 3). Boden et al[2] found that most catastrophic injuries (69%, n = 22, 1.38 per year) occurred when the vaulter landed off the sides or the back of the landing pad, the second most common mechanism was landing in or around the vault box (25%, n = 8, 0.5 per year), and the mechanism was unknown in 2. The 2003 rule change resulted in a more than 3-fold reduction in catastrophic injuries from pole vaulters landing off the sides or the back of the landing pad: 4 injuries (0.44 per year) compared with 1.38 annually before 2003. The most likely explanation is the 2003 NCAA and NFHS rule that mandated enlarging the minimum dimensions of the landing pads from 16 ft × 14 ft to 19 ft 8 inches × 16 ft 5 inches

behind the vault box. It is also possible that the coaches box (preferred landing zone painted or sewn in the middle of the landing pad to encourage landing in the center of the landing pad) and soft surrounding surfaces at the high school level and the general increased awareness and emphasis on safety for coaches and athletes have played a role in reducing the number of catastrophic injuries. All 4 of the athletes who missed the sides or rear of the landing pads after the 2003 rule changes were participating at the college level and landed on hard, unpadded surfaces. If the NCAA mandated a rule requiring soft surrounding surfaces similar to the NFHS's rule, and all colleges were in compliance with the minimum dimension landing pad rule, there may have been no catastrophic injuries from athletes missing the sides or back of the landing pad after 2003.[3] None of the catastrophic injuries in the current study or the prior study[2] occurred because of an athlete landing on a surrounding surface of grass, dirt, sand, wood chips, or 2 inches of padding.

Although the number of catastrophic injuries from athletes missing the sides and back of the landing pads decreased dramatically compared with the previous study,[2] the annual number of injuries from athletes landing in the vault box more than tripled (1.55 and 0.5, respectively), which is a cause for concern. There are several possible explanations for the increased rate of vault box injuries. First, in 1995, the NFHS rules committee mandated that "the vaulter's weight shall be at or below the manufacturer's pole rating."[6] This rule was instituted to encourage athletes to use a lower hand hold to reduce pole bend and lower the risk of control problems, for example, overshooting the landing pad, landing off the sides, landing in the vault box, and/or the pole breaking. However, the stiffer poles are more resistant to rotating to vertical. If the pole resistance is too great for the vaulter's take-off energy, the pole vaulter becomes stranded and may land in the vault box. This relationship requires additional study. Second, most of these pole vaulters were relatively inexperienced (2 years) amateurs with an average personal best of just over 10 ft. It is difficult to determine if these numbers plateau, increase, or decrease with more years of vaulting. It is likely that elite pole vaulters land less frequently in the vault box but have more catastrophic results when they do because they fall from higher heights and have higher grips on the pole.

In 2003, in addition to mandating enlarged landing pads, the NFHS required that exposed surfaces around the vault box be covered with "a minimum of 2-inch dense foam padding," and the NCAA required that these surfaces be covered with "a collar of 2 to 4 inches of padding of uniform thickness."[3,8] Many of the vault box injuries in this study occurred when the athletes landed on the exposed surfaces surrounding the sides or back edges of the vault box or a combination of these surfaces and the vault box. In spite of the NCAA and NFHS rules requiring padding in the box collar, many facilities were in noncompliance at the time of the catastrophic vault box injury in this study. One of the authors has also noted a high rate of noncompliance with this rule at track and field meets. Therefore, strict enforcement of this rule is important, and specific standards regarding the shock attenuation capabilities of the padding used in box collars are needed.

Although the current report focuses on catastrophic pole vaulting injuries, it is clear from our survey that numerous noncatastrophic injuries occur each year from pole vaulters landing in the vault box. Based on the number of participants in the survey and their average number of years pole vaulting, it can be extrapolated that there may be more than 1000 noncatastrophic injuries requiring medical attention each year from pole vaulters landing in the vault box.

There was a marked change in the injury rate by level of participation between the pre- and post-2003 data. From the fall of 1982 through the spring of 2010, the NCCSIR reported that the direct catastrophic injury rates per 100,000 athletes for all sports combined for high school and college were 0.62 and 2.54, respectively.[7] Our post-2003 results showed a direct catastrophic rate of 0.7 per 100,000 high school pole vaulters, comparable with the overall catastrophic injury incidence for all high school sports. However, our 28.4 post-2003 overall rate of catastrophic injuries for college pole vaulters was markedly higher than the previously reported combined rate of 2.54[7] for all college sports. In addition, Boden et al[2] found injuries in 78% of high school and 9% of college pole vaulters, a startling contrast to our current findings of fewer high school (40%) than college (52%) level injuries. If participation numbers are accounted for, the post-2003 incidence per 100,000 pole vaulters was approximately 30-fold higher in college than in high school pole vaulters. These findings indicate a need for more emphasis on prevention measures at the college level.

Information on injury according to gender is difficult to compare because of the scarcity of gender-specific information before 2003. In the current study, we found the post-2003 direct catastrophic injury rate was 1.1 in male vaulters and 0.30 in female vaulters per 100,000 high school pole vaulters and 38.5 for men and 13.1 for women per 100,000 college pole vaulters. At the college level, both the male and female rates were higher than any other sport assessed by the NCCSIR.[7] For male college athletes, pole vaulting rates were followed by gymnastics (25.05), ice hockey (10.22), football (9.5), and lacrosse (5.28) and for female college athletes were followed by skiing (12.46), equestrianism (10.85), gymnastics (4.8), and ice hockey (4.71).[7] However, according to the NCCSIR, the greatest number of direct catastrophic injuries occurs in football for male athletes and in cheerleading for female athletes. Unlike a previous study that reported no injuries in female pole vaulters,[2] the current study identified 3 injured female athletes. This increase may be the result of the rise in the number of female participants over the past decade.

With regard to age, injured athletes in the current study were slightly older than those in the previous study: 19 versus 17.5[2] years, respectively. The current study's higher age for injured athletes may be the result of larger landing pads preventing injuries in high school athletes, whereas older college athletes are attempting higher vaults, are gripping the pole higher, and may be stranded over the vault box.

The incidence of catastrophic pole vaulting injuries is highest at the elite level. According to the National Pole Vault Safety Committee, 8 catastrophic injuries have occurred in 350 male athletes in the United States who have pole vaulted 17 ft 6.75 inches (5.35 m) or higher since 1971, an incidence of 2286 per 100,000, or 2.3 per 100 pole vaulters. There was 1 catastrophic injury in 55 female pole vaulters in the United States who have cleared 14 ft (4.25 m) or higher, an incidence of 1818 per 100,000, or 1.8 per 100 pole vaulters. These heights were selected because they often represent the minimum qualifying standards for participation in USATF national championships. Many of these athletes were injured while vaulting in competitions governed by USATF rules or International Association of Athletics Federation rules, neither of which requires the use of a box collar or the padding of hard surfaces surrounding the landing pad. Therefore, the higher catastrophic injury rate for these elite pole vaulters, as well as the higher rate for collegiate compared with high school athletes after 2003, may be a result of the higher heights from which they are falling and the less stringent rules regarding padding of hard surfaces and the box collar.

There are several limitations of this study. Although we employed extensive Internet searches and the NCCSIR, it is possible that not all catastrophic injuries were identified, and the incidence of injuries may be even higher. Because prior pole vault articles did not assess participation numbers, we were only able to compare annual injury rates and not incidence values. In this study, the participation numbers were a national estimate based on an extensive review of the exact number of pole vaulters in 2 states. Therefore, it is possible that we underestimated or overestimated the exact incidence of injuries. Despite this limitation, this is the first peer-reviewed article on pole vault injuries that attempts to determine the number of pole vaulters.

CONCLUSION

The 2003 rule changes that mandated a larger landing pad have dramatically reduced the number of catastrophic injuries, especially fatalities, from pole vaulters landing off the back or sides of the landing pads. However, the annual rate of catastrophic injuries from pole vaulters landing in the vault box has tripled over the last decade and remains a major problem. The risk of catastrophic vault box injuries increases at the college and professional levels as the attempted vault heights increase. Potential preventive strategies that require additional research include developing materials with appropriate shock absorption capability for the box collar, padding the sides and bottom of the plant box, and making the vault box narrower. A study is currently in progress to test these preventive strategies. The dimensions of the box collar and the pole, especially the stiffness and proper grip heights, as well as the ideal position for the crossbar, also require additional study. A rule that disqualifies pole vaulters if they land outside of a preferred landing zone in the center of the landing pad more than twice during a competition also may be preventative.

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