Women's gymnastics injuries

A 5-year study

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ABSTRACT

A 5-year prospective study on the time course of women's gymnastics injuries was conducted on a successful NCAA Division I team. Gymnasts recorded injuries on a computer terminal or via computer dot sheets immediately before each training session, including the injured body part, the event or activity, and the date of the injury. The definition of injury was "any damaged body part that would interfere with training." Athletes recorded injuries on the 1st day of onset and subsequently until the injury was healed. The initial onset of injury was considered a new injury. Subsequent records of the injury were considered continuing injury.

Thirty-seven athletes participated through five collegiate seasons. They accounted for 5602 total training exposures with an average of 151.4 exposures per athlete. The analyses showed that gymnasts trained with an injury approximately 71% of the exposures, and a new injury could be expected from a gymnast during approximately 9% of the exposures. The largest number of injuries were of the repetitive stress syndrome type. The time series information showed that total injuries tended to increase until the middle of the competitive season, while new injuries showed prominent increases during specific training periods and during competition preparation and performance.

Many studies have sought to gain insight into the nature of injury in gymnastics. The epidemiologic approaches have consisted of retrospective,8,10,11,12 prospective,8,7,14,16,26,27 and case study1,14,17 methods. These types of studies have shown the nature of gymnastics injury with regard to body part, body area, time of year, competition versus practice, skills, sex, and mechanisms.

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preparatory and competitive season, mature athletes and coaches, and easy access to sport science professionals.

The purpose of this study was to prospectively determine the distribution of injuries relative to time and training demands of one successful NCAA Division I women’s gymnastics team. Secondary purposes included recording the distribution of injuries about the body and the distribution of injuries regarding the event or activity causing the injury.

MATERIALS AND METHODS

The University of Utah women’s gymnastics team has participated in injury data collection since 1984, when the principal investigator served as an assistant coach while completing graduate school. The current study occurred during the five competitive seasons from 1986 to 1991.

The data collection method for the 1986–1987 and 1987–1988 seasons consisted of a custom-designed interactive computer program that was run on a personal computer kept in the gymnasium. Each athlete answered questions posed by the computer program every training day, and her individual data were stored for each training day.

The data collection method for the 1988–1989 to 1990–1991 seasons consisted of a custom-designed computer dot sheet. The Scantron computer dot sheets (Scantron Corp., Tustin, CA) and full sheet optical scanner were used to reduce the injury information to computer readable format (Fig. 1). Each athlete was given an identification number and completed a dot sheet form before training on each training day. The Scantron computer sheets were an expansion of the original data collection done by personal computer.

There were several reasons for having the athletes record their own data:

1. There is no current database recording of injuries at the University of Utah via athletic trainers for any sport.
2. The athletic trainer suffers in such data collection efforts because of practical problems getting athletes taped, treated, and ready for practice with a very limited amount of time. Although data recording systems have been proposed for the University of Utah athletic teams, they have never been implemented because the athletic trainers are too busy.
3. The athletes in this study were adults. They received instructions on the recording of injury information at the start of every season. We believe that the athletes were unqualified to diagnose or determine the severity of an injury; therefore, this information was sacrificed to obtain more complete time-based records. These athletes have been training and competing for more than a decade, have been injured many times previously, and are often as old or older than the student trainers that serve them.
4. If the athlete had any question about the recording of an injury she referred to the athletic trainer or coach.
5. Data reduction, printouts, and graphs were done weekly. The principal investigator inspected the results and checked for anomalies on a weekly basis.

Figure 1. Scantron data collection, dot sheet form.

The following injury information was stored for each athlete on each training day: identification number, date, injured body part(s), event or activity that caused the injury, and limitations to training that resulted from the injury. The definition of injury for this study was “any damaged body part that would interfere with training.” Therefore, the common definition of “missed training time” would not give a good indication of the injury milieu found in elite gymnastics.

Athletes recorded an injury the 1st day of onset and every day thereafter until it did not interfere with training. A new injury was defined as the onset of injury with more than 2 injury-free days preceding the record in the series. Old or continuing injuries were considered to be any injury record that was continuously recorded with two or less injury-free records in the series. Total injuries refers to all injury records, new and old.
The importance of these distinctions and definitions was in the analysis and interpretation of the results. Athletes were injured acutely, chronically, and repetitively. This study has operationally defined a “new” injury as the first occurrence or recurrence of the injury after 2 or more recorded injury-free training days. The initial or acute and repetitive types of injuries are covered by “new” injuries. The chronic type of injury was covered by “total” injuries.

Injury information regarding athletes and training must be normalized to account for the number of athletes training and the number of exposures to injury (practices) these athletes had. The approach taken here was to express incidence of injury relative to total exposures, which includes all athletes and all practices. The following injury information is based on the ratio of the number of injuries to the number of exposures.

RESULTS

Descriptive statistics

Thirty-seven athletes participated through the 5 seasons, accounting for 5602 total training exposures. Total exposures per athlete averaged 151.4 (SD, 66.67) exposures, with a range from 49 exposures to 285 exposures per athlete.

Table 1 shows the distribution of injuries by event or activity. The “other” category refers to nongymnastics injuries. The “unknown” category refers to an unknown direct cause and is interpreted to mean the repetitive stress syndrome. This is due to the common situation of an athlete reporting a new or continuing injury for which the athlete cannot determine a direct cause. The athlete could not recall falling, a specific skill or repetition, or some other marker that could be considered causal and therefore be codable by event or activity. Uncodable indicates that the athlete recorded an injury but the event/activity was not available. Tumbling was coded separately from floor exercise because it is normally trained separately from floor exercise. The floor exercise routine consists of tumbling, acrobatic elements, and dance. The gymnast spends a considerable amount of training time tumbling completely separate from the other floor exercise components. The only time that all of the components of floor exercise are trained together is during the routine preparation period of training and the competitive period.

The total injuries/exposures ratios indicated that gymnasts trained with an injury approximately 7% of the time, and that a new injury could be expected from a gymnast approximately 9% of the time. The unknown/repetitive stress syndrome category ranked first in incidence of injury in both the total and new injury reports, accounting for 38% of the total reports and 31% of the new injury reports. The second ranked cause of injury in both the total and new injuries belonged to tumbling, with uneven bars third.

Table 2 shows total injury information regarding the body part injured. The right side of the body was injured more than the left side of the body (Z11 = −9.0, P < 0.01), and the lower extremity (i.e., hip and below) was injured more than the upper extremity (Z13 = −16.3, P < 0.01), by tests of proportions. Note that low back injuries led in injury records, followed by shoulders, shins, ankles, and wrists. Disregarding side of the body, the leading body part injured was the shoulder.

Table 3 shows new injuries by body part. Again, there was a statistically significant difference between the left side and the right side of the body (Z11 = −9.0, P < 0.01), and the upper extremity and the lower extremity (Z13 = −12.9, P < 0.01), by tests of proportions. New injuries were also led by the lower back. The other body parts were mixed with regard to rank depending on the side of the body. Wrist, shoulder, knee, shin, ankle, and heel had relatively higher percentages of involvement.

Descriptive time series

The training period for women’s intercollegiate gymnastics at the University of Utah runs from mid-September to mid-April. The ratios of injuries to exposures across the competitive seasons are shown in Figures 2 and 3. Figure 2 shows the total injuries/exposures and the training demands of each period. A running average across five data points of the ratios was used to reduce the noise of the data. Note the

<table>
<thead>
<tr>
<th>Event/activity</th>
<th>Total injuries</th>
<th>Injuries recorded</th>
<th>New injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Injuries/ exposure</td>
<td>%</td>
</tr>
<tr>
<td>Vault</td>
<td>185</td>
<td>0.033</td>
<td>4.67</td>
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<td>Uneven bars</td>
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<td>0.068</td>
<td>9.56</td>
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<td>Balance beam</td>
<td>217</td>
<td>0.039</td>
<td>5.48</td>
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<tr>
<td>Floor exercise</td>
<td>228</td>
<td>0.041</td>
<td>5.75</td>
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<tr>
<td>Tumbling</td>
<td>940</td>
<td>0.169</td>
<td>23.72</td>
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<tr>
<td>Conditioning</td>
<td>10</td>
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<td>0.25</td>
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<tr>
<td>Other</td>
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<td>Unk/rep stress syn*</td>
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<td>38.23</td>
</tr>
<tr>
<td>Uncodable</td>
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<td>0.064</td>
<td>7.77</td>
</tr>
<tr>
<td>Total</td>
<td>3963</td>
<td>0.707</td>
<td>100.00</td>
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</tbody>
</table>

* Unknown/repetitive stress syndrome.
continuing upward trend of the total injuries/exposures ratios across the entire preparatory and competitive seasons. This appears to indicate that injuries accumulated across the preparatory and competitive seasons. Total injuries/exposures tended to increase throughout the preparatory period peaking during the routine performance segment of training. The peak of total injuries/exposures occurred in roughly the first third of the competitive period, with a secondary peak during the latter third of the competitive period.

Figure 3 shows the injuries/exposures ratios across time for new injuries. The trends for new injuries were clearly different from the continuing or total injuries shown in Figure 2. The large injuries/exposures ratios in the conditioning period were likely due to the problem of getting deconditioned athletes into shape. Most of these athletes did little or no gymnastics during the summer break. The relative number of new injuries increased during skill development and combination development and increased again during routine development and performance. After Christmas break, the athletes returned to training for a brief period of preparation for their first competition, which occurred in mid-January. Of particular interest, one should note that there were 10 peaks of new injuries/exposures ratios during the competitive period and that there were approximately 10 competitions during each competitive season.

**Figure 2. Total injuries per exposures across 5 years.**

**DISCUSSION**

The University of Utah has won a total of seven NCAA National Championships. The competitive standings of the team at the NCAA National Championships during this study were as follows: 1986–1987, second; 1987–1988, second; 1988–1989, fifth; 1989–1990, first; and 1990–1991, second. The gymnastics team trained approximately 5 days per
Figure 3. New injuries per exposures across 5 years.

week, 4 hours per day, with two additional separate workouts of weight training.

The descriptive information depicted in Tables 1 through 3 does not easily translate to the current epidemiologic information in the literature. Moreover, the more global and encompassing definition of injury used here will likely inflate the injury results when compared to other studies. The new injuries/exposures ratios indicate that the gymnasts studied here received a new injury during approximately 9.1% of the exposures, and they recorded a new or continuing injury during approximately 71% of the exposures.

The literature varies considerably in the definition of injury and the relative injury rates determined. Calculating acute injuries received per 100 participants is common. Petrone and Ricciardelli determined this ratio to be 2.4/100 for all skill levels and 5/100 for competitors. Garrick and Requa found this ratio to be 22/100 for gymnastics clubs and 71/100 for college competitors, with an overall injury rate of 39/100. Weiker determined an injury rate of 12% in 873 club gymnasts. Snook studied college female gymnasts for 5 years and found that 70 gymnasts suffered 66 major injuries, resulting in a 94% injury rate. Caine et al. studied elite gymnasts in two private gymnastics clubs for 1 year and determined a baseline injury rate of 1.2 injuries per athlete. Caine et al. determined the injury rate per 100 competitors to be 294/100.

The current study resulted in an injury rate per 100 competitors of 1376/100 for new injuries and 10,711/100 for total injuries. These vastly larger ratios are likely due to the more global definition of injury and the daily data collection. Caine et al. also determined an injury rate of 3.66 injuries per 1000 hours of participation across 47 athletes. Assuming the athletes considered here trained 4 hours during each exposure for 5602 exposures results in 22,408 total training hours. This results in a new injury ratio of 22.7 injuries per 1000 hours and 176.9 new and continuing injuries per 1000 hours across 37 athletes. Again, the large differences are likely due to the difference in injury definition and the data collection procedures. Moreover, it is unlikely that the nature of the exposures was similar among any of these studies.

The distribution of injuries by events or activities is similar to other current literature in gymnastics. The high incidence of repetitive stress syndrome injuries has been documented along with the relatively high incidence of injuries in floor exercise. This study considered tumbling and floor exercise injuries separately because they were usually trained separately. Studies have shown a mixture of events or activities that lead to injury incidence. Sands et al. in a 1984–1985 pilot study at the University of Utah, showed that during one season the uneven bars led the events in injuries, while the next season this distinction was awarded to floor exercise. This points to the concept that different groups of athletes, even in the same training program, may result in different injury profiles.

The distribution of injuries across body parts agrees partially with similar current literature. The low back and lower extremity tend to have a high incidence of injury, along with the wrist. Interestingly, the side of the body injured was significantly different. The right side of the body was injured more frequently than the left side in both new and continuing injuries. The fact that gymnasts have a preferred side of performance is common knowledge to the gymnastics practitioner. The incidence of injuries to the right side of the body represented 55% of the total injuries reported and 65% of the new injuries reported. Conditioning factors in gymnasts have been addressed earlier by Sands et al. and showed that gymnasts were not bilaterally symmetrical in hamstring/quadriceps relationships. This has been further emphasized by recent testing of U.S. national team female gymnasts (Sands, unpublished work in progress).

The injuries/exposures ratios relative to training demands (Figs. 2 and 3) indicate that the onset of training, routine performance, and competitions resulted in more injuries than other training demands. The high incidence of injury during early conditioning may have resulted from the shock of increased work demands on detrained athletes. The high incidence of new and total injuries during routine performance supports similar findings by Sands et al. at the same period of training. This may be due to the higher level of fatigue that is developed when performing longer sequences of skills. The gymnast is faced with a difficult situation in trying to perform flawless exercises while in the process of developing the specific fitness to do so.

The high incidence of injury in connection with competitions is supported by Kerr and Minden, whose results showed a higher incidence of injury as time grew closer to the competitive event. Discussions with the head coach of these athletes indicated that the reason for this was that the athletes are much better protected in training than in competition because of landing in foam pits, spotting, and softer mats. The approximately weekly peaks of injuries during the competitive season, and the number of peaks coinciding with the number of competitions, is a strong argument for the idea that competitions place the athletes at greater risk for new injuries. The largest peak, in late February, corre-
sponded to a "slump" period that had been noted by the team sport psychologist, and was possibly due to midterm tests at the University of Utah, and the initiation of a final push in skill development before the national championships.

The preparation and performance of the routine itself appears to be implicated in the higher incidence of injury. Others have noted that there is a relationship between competitors and noncompetitors, difficulty of the skills, ability of the athlete, and injury. Only one study in our search of the literature did not find a relationship between skill ability or the athlete and injury rate studying relatively low competitive level gymnasts.¹⁵

CONCLUSIONS

Gymnastics for this collegiate women's team appears to have resulted in increased incidence of injury to the shoulder, low back, and the lower extremity (particularly the right side). Repetitive stress syndrome injuries were the most common injury, with tending the event most responsible for injury.

The development of a gymnast through her preparatory period and competitive season is based on differing demands that will prepare her competition routines for performance. The training and performance of full routines in competition appears to be linked to increased incidence of injury. This should indicate to the practitioner that careful preparation of full routines and perhaps exploring increasing routine fitness while performing in a more protected environment could reduce the incidence of injury. Moreover, the high incidence of injury linked with competitions and full routines should call for a reevaluation of competition rules and the performance environment. For example, although the female gymnast is now performing the same types of skills on uneven bars as her male counterpart on the horizontal bar, her matting has remained the same while that of the male gymnast has increased in thickness. The same could be said for the dismount areas of the other apparatus.⁸,¹⁸

Matting is similar to the trapeze artist's net; increasing the thickness of matting has been indicated as a means of reducing injury.¹²,¹³,¹⁴,¹⁸,²¹

The physician serving a collegiate elite gymnastics team should recognize that total injuries tend to accumulate throughout the season. Moreover, the physician should heighten awareness and encourage extra vigilance on the part of the coaches during periods of routine preparation and competitions. On completion of this study, the coaches at the University of Utah have instituted a more aggressive plan of active recovery and strength training to reduce these injury patterns.

Future directions for research should include similar studies in clubs, high schools, and other universities. The use of computers and computer dot sheets makes the data collection procedures simple for the athlete and coach and easy to implement, thereby enhancing compliance and validity.

Although a goal of epidemiologic research is to gain an "overall" profile of injury for a given sport,¹² this may not be possible or desirable in gymnastics. Gymnastics is unlike other sports in that the different levels of performance differ in the skills performed. Most sports perform roughly the same skills at nearly all levels with the distinction being how well the skills are performed. Gymnastics training demands consist of the systematic and long-term learning and performance of more and more difficult and sometimes dangerous skills. Gymnastics training program demands (i.e., levels) appear to be linked to the incidence of injury and should be studied with this clearly in mind.

REFERENCES