

Evaluation of Safety Balls and Faceguards for Prevention of Injuries in Youth Baseball

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BASEBALL IS AN INTEGRAL PART OF the cultural fabric of the United States, in part because it provides a point of initiation for youth into organized team sport.^{1,2} Nearly two thirds of baseball participants are younger than 18 years.³ There is concern, however, about injuries to youth baseball participants, and protective equipment has been widely endorsed and studied as a means of preventing these injuries.⁴⁻¹⁴

Biomechanical studies indicate that safety balls and protective faceguards have the potential to reduce the risk of injury in youth baseball.¹⁵⁻¹⁷ Using data from a survey of injured children seeking emergency department care for baseball injury (n=348), the Consumer Product Safety Commission estimated that up to one third of emergency department visits for youth baseball injury could be prevented if safety balls, faceguards, and safety bases were used universally.⁹ However, this estimate assumes that these devices are 100% effective in preventing injury. The effectiveness of the 2 major types of safety bases, the quick release (break-away) and Hollywood-style, have been previously described,^{10,11} but no epidemiologic study has examined the effectiveness of safety balls and protective faceguards.

The purpose of this study was to evaluate the use of faceguards and safety

See also Patient Page.

Context Safety balls and faceguards are widely used in youth baseball, but their effectiveness in reducing injury is unknown.

Objective To evaluate the association of the use of faceguards and safety balls and injuries in youth baseball.

Design, Setting, and Participants Ecological study using a national database of compensated insurance claims maintained by Little League Baseball Incorporated, combined with data on the number of participants in Little League and data from a census of protective equipment usage for youth aged 5 to 18 years participating in Little League Baseball in the United States during 1997-1999.

Main Outcome Measures Rate of injury and injury rate ratio comparing users with nonusers of protective equipment.

Results A total of 6744240 player-seasons of follow-up and 4233 compensated injury claims were available for analysis. The absolute incidence of compensated injury per 100000 player-seasons was 28.02 (95% confidence interval [CI], 26.76-29.29) for ball-related injury and 2.71 (95% CI, 2.32-3.11) for facial injury. Overall, use of safety balls was associated with a reduced risk of ball-related injury (adjusted rate ratio, 0.77; 95% CI, 0.64-0.93). This reduction was essentially due to 1 type of safety ball, known as the reduced-impact ball (adjusted rate ratio, 0.72; 95% CI, 0.57-0.91). Use of faceguards reduced the risk of facial injury (adjusted rate ratio, 0.65; 95% CI, 0.43-0.98). Metal and plastic guards appeared to be equally effective. Safety balls appeared to be more effective in the minor division (ages 7-12 years) than in the regular division (ages 9-12 years).

Conclusions Reduced-impact balls and faceguards were associated with a reduced risk of injury in youth baseball. These findings support increased usage of these items; however, it should be noted that the absolute incidence of injury in youth baseball is low and that these equipment items do not prevent all injuries.

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balls for preventing injury in youth baseball. This study used a national database of compensated insurance claims maintained by Little League Baseball Incorporated, combined with data on the number of participants in Little League and data from a census of protective equipment usage.

METHODS

We used an ecological design combining data from 3 sources: compensated injury claims filed with Little League Baseball Incorporated (hereafter referred to as Little League), the participation database assembled by Little League, and a national census of the

safety equipment used in Little League, which was specifically conducted for the purposes of this study. The study covered the 1997-1999 regular seasons.

The term *little league* is often used as a generic label for youth baseball; however, only leagues that were chartered

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affiliates of Little League during the study period were included in this study. There are approximately 5 million participants in organized youth baseball leagues in the United States, and approximately 50% of participants compete in leagues affiliated with Little League.³ This study was commissioned by USA Baseball's Medical and Safety Advisory Committee and approved by the institutional review board of the School of Public Health, University of North Carolina at Chapel Hill.

Protective Equipment

We examined the association of faceguards and safety balls with injury. Usage of this protective equipment was at the discretion of the individual leagues in the study. It was not assigned at random. A wide variety of safety balls are currently used in youth baseball. These include tennis balls, rubber balls, cloth balls, and a special type of ball generically known as the reduced-impact ball (also known as the Reduced Impact Factor or RIF ball). The reduced-impact ball is designed to look and play like a regular baseball but has greater deformation on impact than traditional balls, lowering the force transmitted to the child. Reduced-impact balls generally have a polyurethane core, in contrast with the wool yarn wound around a cork core in the traditional baseball. There are 3 main types of reduced-impact balls: reduced-impact 10, reduced-impact 5, and reduced-impact 1. Type 10 is stiffer (harder) than type 5, which is stiffer than type 1.

Protective faceguards are worn when the child is at bat and when running the bases. The faceguards studied largely comprised the metal mesh guards and the clear plastic protective visors. Both faceguards are designed to provide minimal interference with the batter's field of vision.

Protective Equipment Usage, Census of Safety Equipment Usage

To provide data on exposure to safety balls and faceguards, we conducted a Census of Safety Equipment Usage in Little League in the 1997-1999 seasons.

The census was conducted under the auspices of Little League Baseball and was conducted from Little League's national office in Williamsport, Pa. To be eligible for inclusion in the census, leagues had to take up the optional Little League insurance coverage (97% of leagues). They also had to have a designated safety officer (87% of leagues accepting the insurance option).

Equipment data were collected by directly contacting every eligible league. A representative from each league (typically either the league safety officer or the league president) completed a baseline equipment usage questionnaire for his/her league in 1997. Leagues were followed up for 2 additional years (1998 and 1999) to collect data on any changes in their usage of safety equipment. The study population was dynamic; leagues that affiliated with Little League in 1998 or 1999 were enrolled in the study, administered a baseline survey, and followed up for the remainder of the study period. Leagues that defiliated with Little League in 1998 or 1999 were followed up only during the period they were affiliated.

The survey instrument collected information on the usage of safety balls and faceguards in each of the divisions offered by each league. Only protective equipment usage pertaining to baseball play during the regular season was collected (ie, postseason play and softball were excluded).

In 1997, the questionnaire was initially mailed with telephone follow-up of the nonresponders. In 1998 and 1999, telephone calls were used exclusively to contact the leagues and update the database to reflect any changes in equipment usage from the previous year. The response rates were 94% in 1997, 98% in 1998, and 99% in 1999. The final census population numbered 5029 leagues in 1997, 5085 leagues in 1998, and 5055 leagues in 1999, representing 79% of all Little League affiliates in the United States.

Covariates

Little League's participation database was accessed to obtain data on the num-

ber of participants in each division in each league. Little League maintains detailed information on all affiliated leagues. This includes the divisions operated by each league and the number of players competing in each division in each league.

Division (level of play) was a priori considered likely to be a strong confounder of any association between protective equipment and injury. Assignment to level of play was based on age and ability. Any confounding effect of age was assumed to be subsumed within the stronger confounding effect of level of play. We did not control for potential residual confounding effects of age within level of division. The playing population above the T-ball level was overwhelmingly male, preventing us from investigating sex as a covariate. We did not collect data on the type of bats used in each league. Little League regulations constrain the physical characteristics of the bats approved for use in affiliated leagues.

Challenger division, which offers competition for children with special needs, was excluded because there were too few injuries to permit meaningful analysis. To avoid overstratification of the data, we grouped the 8 remaining divisions into 4 categories, as follows: T-ball (ages 5-8 years), Little League minor (ages 7-12 years), Little League regular (ages 9-12 years), and upper leagues (junior, senior-minor, senior, big league minor, and big league; ages 13-18 years).

Ascertainment of Injuries, Compensated Claims Database

The outcome of interest was defined as a baseball injury resulting in compensation under Little League's insurance policy. These data were obtained from Little League's compensated claims database. Injuries were restricted to those in scheduled games or practices during the regular season for 1997-1999. Postseason injuries were excluded. The data were limited to baseball and T-ball (ie, softball was excluded). A ball-related injury was defined as an injury due to contact with a batted, pitched,

or thrown ball, and a facial injury was defined as an injury to the eye, face, or nose, while a player was either at bat or running the bases. The descriptive epidemiology of injury in Little League has been previously reported.¹³

We also analyzed separately the subgroup of higher-severity injuries that were considered likely to result in long-term temporary disability. Higher-severity injuries were defined as dismemberments, fractures, and dislocations, and accounted for 38% of all compensated claims in the study.

Little League provides, on a national basis, the option of insurance coverage for all affiliates. This insurance includes coverage for medical and related expenses for injuries to participants. There is a \$50 deductible per claim and all claims are lodged through Little League. Affiliates may accept or decline the coverage; 97% chose to accept it during the 3-year period.

In 1997 and 1998, claims that did not result in compensation were not routinely electronically recorded by Little League; however, starting in 1999, claims were electronically recorded irrespective of whether they were ultimately compensated or not. In 1999, 54% of all registered claims were compensated. Claims were not compensated if they were judged to be invalid under the policy or if the losses did not reach the \$50 deductible.

Statistical Analysis

The main outcome of interest was the injury rate, defined as the number of compensated injury claims divided by the number of player-seasons at risk ($\times 100\,000$ for convenience). To calculate injury rates, the compensated claims, participation, and safety equipment usage databases were linked together. The resulting data were summarized to give the number of compensated injuries and player-seasons of follow-up for each division in every study league. Rate ratios (RRs) were calculated to assess the effect of each protective equipment item on the injury rate. Traditional (nonsafety) equipment was the referent category for all

RRs, and 95% confidence intervals (CIs) were used to assess the relative precision of the RRs.

Initially, a comprehensive stratified analysis of the data, using Mantel-Haenszel-type estimators to control for division, was performed.¹⁸⁻²⁰ Based on the results of the stratified analysis, a multivariate analysis was conducted. The multivariate analysis used a multilevel, or hierarchical, model.^{21,22} A multilevel model was used because protective equipment usage is an ecological decision made by the league, not by the individual player.^{22,23} Furthermore, this model accounts for the lack of statistical independence of teams within leagues, which could have arisen if some study leagues tended to be more safety-conscious than others.

Because the rate of injury was the outcome of interest, we fit the multilevel form of the Poisson regression model to the data.²⁴ The multilevel Poisson regression model belongs to a general family of models known as generalized linear mixed models.²⁵ Multilevel Poisson regression is implemented using a log-link function and an overdispersed Poisson model for residual variation, with the rate denominator (number of player-seasons at risk) included in the model as an offset term.^{24,25} A random effect was used to model a separate intercept for each league in the study, under the constraint that these league-specific intercepts are normally distributed.^{24,25} The model was fit using SAS's PROC NLMIXED version 8.02 (SAS Institute Inc, Cary, NC), which uses Gauss-Hermite quadrature to integrate an approximate likelihood function.²⁵

To assess division as an effect-measure modifier (modifier), we examined the effect of safety equipment stratified by division. We also used the likelihood ratio test to compare models with and without the interaction term for protective equipment by division. Limitations of this type of test include limited ability to assess departures from jointly additive (as opposed to jointly multiplicative) effects, and poor power to distinguish between additive and multiplicative joint ef-

fects.^{26,27} Division was assessed as a confounder by comparing RRs unadjusted and adjusted for division.

It is possible that an item of protective equipment could decrease the risk of certain types of injuries but increase the risk for other types of injury. For example, it might be possible that facemasks reduce the risk of facial injuries but increase the risk of neck injuries. For this reason, in addition to modeling the rate for ball-related and facial injury, we fit multilevel Poisson regression models to estimate the effect of safety balls and faceguards on the overall injury rate. We also fit multilevel Poisson regression models restricted to high-severity injuries (dismemberments, fractures, and dislocations).

To determine whether nuances of insurance compensation could be a potential source of bias in this study, uncompensated injury claims for 1999 were accessed, combined with compensated injury claims for 1999, and all analyses were repeated. Uncompensated injury claims were defined in an analogous fashion to compensated injury claims (ie, injuries to players in regularly scheduled games or practices during the regular baseball or T-ball season).

RESULTS

A total of 6744240 player-seasons of follow-up and 4233 compensated injury claims were available for analysis. Missing data resulted in smaller study size for some analyses. Compensated injury claims will hereafter be referred to as injuries.

Descriptive information on the distribution of protective equipment and injuries by division is presented in TABLE 1 (these data have been annualized to facilitate interpretation). Nearly one half of all the compensated injuries were in the Little League regular division. Risk of injury increased with level of competition, but usage of safety balls and faceguards decreased with increasing level of competition, creating the potential for confounding by division. A mean 73.0% of leagues

used safety balls in at least 1 division, and 34.3% used faceguards in at least 1 division.

Ball-Related Injury

The majority of injuries (44.6%) were ball-related (n=1890). The absolute incidence of compensated injury claims per 100 000 player-seasons was 28.02 (95% CI, 26.76-29.29) for ball-related injury. Overall, safety balls were associated with a reduced risk of ball-related injury. The RR for all types of safety balls combined vs traditional balls after adjusting for division was 0.77 (95% CI, 0.64-0.93), indicating a protective association.

There was an indication that division modified the effect of safety balls (TABLE 2). The association appeared to be stronger in the minor division than in the regular division, and the likelihood ratio test P value for statistical interaction was .05. However, considerable overlap was observed in the CIs for the other divisions, complicating the assessment of modification. Division was a strong confounder of the safety-ball association. The RR for all types of safety balls combined, unadjusted for division, was 0.20 (95% CI, 0.17-0.23). All safety-ball RRs reported were adjusted for division.

When the various subcategories of safety balls were examined, the reduced-impact ball was consistently associated with a reduced risk of injury

(TABLE 3). The adjusted RR for all types of reduced-impact ball combined vs traditional balls was 0.72 (95% CI, 0.57-0.91). The other main types of safety balls (rubber, tennis, and cloth balls) did not appear to be associated with a reduction in injury risk (adjusted RR, 1.04; 95% CI, 0.68-1.57). Interpretation of the RR for the mixed/other category is problematic, because this group included leagues using reduced-impact balls in combination with other types of safety balls (27.7% of mixed/other) and safety balls in combination with traditional balls (20.3% of mixed/other).

Infielders (34.7%), batters (27.9%), and outfielders (12.1%) were the playing positions most commonly injured by balls. We theorized a priori that safety balls would have a greater protective effect in higher velocity impacts (eg, when at bat); however, the

ball injury RR did not appear to vary when stratified by playing position. The adjusted RR for safety balls vs traditional balls was 0.81 (95% CI, 0.58-1.12) for batters, 0.76 (95% CI, 0.57-1.02) for infielders, and 0.78 (95% CI, 0.47-1.29) for outfielders.

Ball-related injuries were evenly split between batted balls (36.0%), thrown balls (31.4%), and pitched balls (28.6%; unspecified balls accounted for 4.1%). How the ball acquired its velocity appeared to make almost no difference to the protective association of safety balls. The adjusted RR for safety balls vs traditional balls was 0.79 (95% CI, 0.59-1.05) for batted balls, 0.84 (95% CI, 0.61-1.15) for pitched balls, and 0.67 (95% CI, 0.49-0.93) for thrown balls.

For all types of injuries, ball-related and non-ball-related combined, the adjusted RR for safety balls vs traditional balls was 0.84 (95% CI, 0.73-0.97). The

Table 1. Annualized Distribution of Participants, Injuries, and Safety Equipment*

Division	Mean No. (%)			
	Participants, per Year	Compensated Injury Claims, per Year	Leagues Using Safety Balls, per Year†	Leagues Using Faceguards, per Year†
T-ball	615 765 (27.4)	39 (2.7)	3226 (85.4)	995 (26.0)
Little League minor	827 440 (36.8)	302 (21.4)	701 (15.1)	1211 (27.5)
Little League regular	519 350 (23.1)	676 (47.9)	404 (8.2)	1069 (23.9)
Upper leagues	285 525 (12.7)	394 (27.9)	682 (9.9)	969 (15.6)
Total	2 248 080 (100)	1411 (100)	3675 (73.0)	1625 (34.3)

*Because of rounding, percentages may not all total 100.
 †Each league has several divisions and within a league the divisions have different policies for using safety equipment (safety balls vs faceguards). For each division, percentage of all study leagues fielding teams in that division. For total, percentage of all study leagues offering the safety device for at least 1 of their divisions.

Table 2. Association of Safety Balls and Faceguards With Risk of Injury, by Level of Competition

Division	No. of Injury Claims		Total No. of Player-Seasons		Compensated Injury Claim Rate (per 100 000 Player-Seasons)		
	Safety Equipment	Traditional Equipment	Safety Equipment	Traditional Equipment	Safety Equipment	Traditional Equipment	Rate Ratio (95% Confidence Interval)*
Ball-Related Injury†							
T-ball	22	6	1 174 950	172 620	1.88	3.48	0.54 (0.22-1.33)
Minor	41	399	329 295	1 698 435	12.45	23.49	0.54 (0.38-0.75)
Regular	79	960	100 455	1 187 640	78.64	80.83	0.98 (0.77-1.25)
Upper	11	372	19 035	554 130	57.79	67.13	0.88 (0.48-1.63)
Facial Injury†							
T-ball	0	1	328 245	1 035 105	0.00	0.10	Not estimable
Minor	9	33	484 830	1 442 340	1.86	2.29	0.80 (0.38-1.70)
Regular	14	84	278 685	891 270	5.02	9.42	0.53 (0.30-0.95)
Upper	5	37	66 705	444 060	7.49	8.33	0.90 (0.35-2.29)

*Traditional equipment is the referent category. Rate ratio estimated using multilevel Poisson regression.
 †For ball-related injury, likelihood ratio test for statistical interaction (safety ball by division) is $\chi^2 = 8.1$ and $P = .05$; for facial injury (faceguard by division), $\chi^2 = 1.6$ and $P = .65$.

analogous RR for the higher severity ball-related injuries (n= 701) was 0.91 (95% CI, 0.66-1.24).

Facial Injuries While at Bat or Running the Bases

In contrast with ball-related injuries, facial injuries accounted for only 4.3% of all injuries (n= 183). The absolute incidence of compensated injury claims per 100000 player-seasons was 2.71 (95% CI, 2.32-3.11) for facial injury. Overall, faceguards were associated with a reduced risk of facial injury. The RR for both types of faceguards combined vs no faceguard was 0.65 (95% CI, 0.43-0.98), after adjusting for division. There was no strong evidence of modification by the RR by division, considering the overlap in the stratum-specific confidence intervals (Table 2). Division was a weak confounder of the faceguard association. The RR for all types of faceguard combined unadjusted for division was 0.60 (95% CI, 0.40-0.89). In the interests of comparability between the safety ball and faceguard results, all faceguard RRs reported are adjusted for division.

When the 2 types of faceguard were examined, there was an indication that plastic faceguards might be more effective than metal, but there were too

few injury claims to determine if this difference was real or an artifact of random variation (Table 3). The mixed/other category for faceguards included situations where faceguards were not required but were available for voluntary use (51.1%), and where leagues used both metal and plastic faceguards in combination (25.0%).

Facial injuries occurred when at bat (80.0%) and running the bases (20.0%). Facial injuries in other playing positions were excluded from analysis, because they would not have been prevented through the use of a faceguard. The protective association of faceguards appeared to be similar for batters (adjusted RR, 0.64; 95% CI, 0.41-0.99) and base runners (adjusted RR, 0.72; 95% CI, 0.28-1.89). For all types of injuries, facial and nonfacial combined, the adjusted RR for faceguards vs no faceguard was 0.86 (95% CI, 0.78-0.96). The analogous RR for higher-severity facial injuries (n=97) was 0.85 (95% CI, 0.47-1.53).

Analysis of Compensated and Uncompensated Injury Claims

Uncompensated injury claims for 1999 were combined with the 1999 compensated claims and all analyses were repeated to determine whether nuances

of insurance compensation could be responsible for the observed protective associations. For safety balls vs traditional balls, the adjusted RR was 0.77 (95% CI, 0.62-0.97). For faceguards vs no faceguards, the adjusted RR was 0.69 (95% CI, 0.37-1.30).

COMMENT

This 3-year study of Little League Baseball found that the use of safety balls and faceguards in this population was associated with a reduced risk of injury. The use of safety balls was associated with a 23% (RR, 0.77) reduced risk of ball-related injury, and faceguards with a 35% (RR, 0.65) reduced risk of facial injury. Reduced-impact balls appeared to be the most effective type of safety ball (28% reduction; RR, 0.72). There was no compelling evidence of any difference between plastic and metal faceguards. The protective benefits of safety balls may be stronger in the minor division than in regular division.

Strengths and Limitations

This was a large study (more than 6.7 million player-seasons) with a high rate of follow-up. All 50 US states were represented in the study. As with any observational study, however, the observed reductions in injury risk are

Table 3. Association of Safety Ball and Faceguard Usage With Risk of Injury

	No. of Injury Claims	Total No. of Player-Seasons	Injury Claim Rate (per 100 000 Player-Seasons)*	Adjusted Rate Ratio (95% Confidence Interval)†
Ball-Related Injury				
Traditional ball	1737	3 612 825	48.08	1.00
All safety balls combined	153	1 632 735	9.37	0.77 (0.64-0.93)
Rubber/tennis/cloth	39	374 010	10.43	1.04 (0.68-1.57)
All reduced-impact balls combined	86	901 290	9.54	0.72 (0.57-0.91)
Reduced-impact 1‡	33	418 650	7.88	0.80 (0.55-1.14)
Reduced-impact 5‡	40	372 225	10.75	0.75 (0.54-1.04)
Reduced-impact 10‡	13	110 415	11.77	0.52 (0.30-0.92)
Mixed/other	28	348 435	8.04	0.64 (0.43-0.95)
Facial Injury				
No faceguard	155	3 812 775	4.07	1.00
All faceguards combined	28	1 158 465	2.42	0.65 (0.43-0.98)
Plastic faceguard	7	402 885	1.74	0.50 (0.23-1.08)
Metal faceguard	13	522 180	2.49	0.67 (0.37-1.18)
Mixed/other faceguards	8	233 400	3.43	0.83 (0.40-1.71)

*Rate of compensated injury claims, not controlling for division.

†Adjusted for division using multilevel Poisson regression.

‡Reduced-impact 10 ball is stiffer (harder) than reduced-impact 5 ball, which is stiffer than reduced-impact 1 ball.

potentially subject to confounding bias (ie, they may be due to differences between the leagues other than the equipment used).

Another limitation of this study is the use of insurance records to identify injuries. It is possible that some Little League injuries during the study period did not result in compensated claims and therefore were not included in this study. Legitimate injuries that were registered with Little League may not have been compensated (undercompensation bias). In addition, some injuries may not even have been registered with Little League (underregistration bias).

Undercompensation bias would only arise if the probability of compensation was associated with usage of safety equipment. This seems unlikely, because data on the type of equipment used is not routinely available to the claim assessors. Furthermore, when uncompensated and compensated claims for 1 year (1999) were combined together and analyzed, the results were similar to those based on only compensated claims.

To assist in quantifying to what extent underregistration could have introduced bias, a small sensitivity analysis was conducted. Simple deterministic methods were used to produce corrected RRs under various hypothetical underregistration scenarios.²⁸ Our working assumptions for the sensitivity analysis were that specificity was 100% (ie, all registered injuries represented true injuries) and that division of play was measured without error. An important and well-known²⁸ first result from the sensitivity analysis was that no underregistration bias exists in the study findings if the hypothetical underreporting was nondifferential with respect to use of safety equipment. In other words, underregistration would not have biased the study findings so long as the probability that an injury registered with Little League was independent of use of safety balls or faceguards in that league.

The second result from the sensitivity analysis was that differential under-

registration could have created bias in the study findings; however, this bias was small as long as underreporting and equipment use were not strongly associated. For example, if the difference in the underregistration rates between users and nonusers of safety equipment was 10% or less and the proportion of unregistered injuries was no more than 30%, only a modest degree of bias was present in the study findings (RR, 0.77 for safety balls and 0.65 for faceguards). In this scenario, the corrected RRs ranged from 0.67 to 0.88 for safety balls and 0.57 to 0.74 for faceguards. More bias was present if the difference in underregistration rates between users and nonusers was 15% or less, with corrected RRs from 0.63 to 0.90 for safety balls and 0.53 to 0.79 for faceguards. A very high proportion of unregistered injuries of 50% or less resulted in only modest bias if the difference in the underregistration rate between users and nonusers was small, 5% or less. The corrected RRs ranged from 0.70 to 0.84 for safety balls and 0.59 to 0.72 for faceguards in this scenario. In summary, the sensitivity analysis results suggest that underregistration is not a threat to study validity as long as it is nondifferential or weakly differential with respect to usage of safety equipment.

Interpretation of Findings

The findings are generally consistent with previous research. The overall distribution and incidence of injuries observed are similar to those reported elsewhere.^{9,12} Reanalysis of data from a previous, much smaller, epidemiologic study of safety balls yields an RR of 0.87 for reduced-impact balls, similar to that observed in this study.¹² A recent epidemiologic faceguard study indicated a reduction (RR, 0.77) in facial injuries following use of the faceguard.²⁹

Theoretical biomechanical studies have indicated that baseballs with lower mass and less stiffness have a reduced potential for injury.³⁰ Laboratory studies have shown that reduced-impact balls are less likely to result in head injury and skull fracture.^{16,17} Some experimental models suggest that safety

balls also reduce the risk of sudden death from chest-wall impacts (commotio cordis),^{31,32} although this claim has been debated.^{9,33} Although there is concern about the potential for a softer baseball to penetrate the orbit of the eye more deeply, this hazard is only present in extremely soft balls.¹⁷ This concern can be reduced if safety balls and faceguards that conform to current safety standards are used.¹⁴

The most important barrier to increased acceptance of the reduced-impact ball may be dissatisfaction with the perceived performance characteristics or play of the ball. In the first year of our study (1997), 63 leagues reported that they had tried reduced-impact balls in previous years but had discontinued their use, frequently citing problems with the bounce of the ball.³⁴ On the other hand, a laboratory study reported that when pitching, throwing, and batting under blinded conditions (with no identifying notation on the ball), adults cannot distinguish between a traditional ball and a safety ball, which has as little as 20% of the traditional ball's hardness, and children (11-14 years) cannot distinguish between a traditional ball and a safety ball with as little as 15% hardness.¹⁷ Thus, the concerns about the play of safety balls possibly revolve around the perception of the ball's play, rather than the actual performance of the ball.

Although our findings indicate that safety balls and faceguards are associated with a reduced risk of ball-related and facial injuries, it is clear that they are not 100% protective. Thus, the proportion of injuries that would be prevented if organized youth baseball were to universally mandate the use of safety balls and faceguards would be less than the 32% estimated by the Consumer Product Safety Commission.⁹

Conclusions

These findings support the expanded use of reduced-impact balls and faceguards in youth baseball. It should be noted, however, that the absolute incidence of compensated injury claims in youth baseball is low and that these equip-

ment items do not prevent all injuries. Given the greater incidence of ball-related injury relative to facial injury, we suggest that leagues with limited resources consider pursuing the implementation of safety balls initially, followed by implementation of faceguards.

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