

Severity of fall injuries on sand or grass in playgrounds

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Playground injuries are a major public health problem.¹⁻³ Laboratory studies have recommended sand, pearock, synthetic materials, or wood chips as protective surfaces beneath equipment,² and epidemiological studies have confirmed that hard surfaces are dangerous. However, some questions remain about grass.¹⁻³ To compare the protection offered by grass and sand, public and residential playgrounds need to be considered. Most sand surfaces are in public playgrounds, while grass is used mostly at home where up to 25% of accidents occur.²⁻⁴ This study aimed at comparing the risk of severe injuries after a fall on sand or on grass.

Methods

During the summers of 1991 and 1995, children aged 1 to 14, who attended the emergency department of Montreal's two children's hospitals for a fall related injury involving playground equipment, were identified (n=930). The following information was gathered during a telephone interview with the parents: age, sex, mother tongue, mother's educational level, family size, location (Island of Montreal or not), mechanism of the accident and of the injury, type of playground (home, public, other), supervision (presence of an adult), mean number of playground visits weekly, type of equipment, surface material, nature of injury and body part injured, and number of medical consultations for injuries in the past year. A 91% response rate was achieved. The nature of the injury reported was validated using information from the doctor.⁵ This variable represents one of our two main outcomes, and it was divided into two categories. The "fracture and head injury" category includes concussions, skull fractures, or head contusions (n=110), fractures and dislocations (n=508). All others types of injuries were grouped into the "other" category. This classification by nature of injury

was added to the Abbreviated Injury Scale (AIS) where 1 corresponds to a minor injury and 6 to death,⁶ because it is more intuitive to most public health professionals involved in injury prevention. Nevertheless, nature of injury categories were compared with the AIS severity score (table 1). As expected, 95% in the "other" category were AIS 1 whereas only 15% of the fractures and head injuries were AIS 1. The analysis was done with both types of outcome, nature and severity. The results with the nature provide information regarding the risk of fracture and head injuries of any type, whereas the analyses with the AIS reflect the risk of having a more severe injury (AIS 2-3).

The surface was divided in three categories: sand, grass, and others. Some playgrounds were visited by observers who had received special training from us to assess some safety aspects of public playgrounds. Therefore, the type of surface material reported independently by the observers and the parents were compared. The latter tend to consider surfaces safer than the observers, but this was not associated with the severity of the injury.⁵

Univariate and bivariate analyses were initially conducted and crude odd ratios estimated. Logistic regressions were then performed to verify the association between surface, nature, and severity of injury, after adjusting for potential risk factors and confounders (age, location of the accident, month of the injury, number of medical visits for an injury per year, playground utilisation). Other variables weakly associated with injury severity in the initial model were not retained in the final model if they did not bias the effects. Their adjusted odds ratios (ORa) were, none the less, estimated in the final model. The type of playground and surface were highly correlated, thus only the surface was included in the

Table 1 Distribution of injuries by nature, severity (AIS) and body part

| Nature of injury | Number of cases | | AIS level (%)† | | | Body part (%)‡ | | | | |
|---------------------------------|-----------------|-----|----------------|-------|-------|----------------|------|------------|------------|--------|
| | (n=930) | %* | AIS 1 | AIS 2 | AIS 3 | Head | Face | Lower limb | Upper limb | Others |
| <i>Fracture and head injury</i> | | | | | | | | | | |
| Head injury§ | 110 | 12 | 58 | 21 | 21 | 94 | 6 | 0 | 0 | 0 |
| Fracture and dislocation¶ | 508 | 55 | 5 | 73 | 22 | 0 | 0 | 11 | 87 | 2 |
| Total severe injury | 618 | 66 | 15 | 63 | 22 | 17 | 1 | 9 | 71 | 2 |
| <i>Others</i> | | | | | | | | | | |
| Strain/sprain | 103 | 11 | 90 | 9 | 1 | 0 | 0 | 51 | 36 | 13 |
| Contusion | 99 | 11 | 99 | 1 | 0 | 16 | 4 | 28 | 21 | 31 |
| Laceration | 69 | 8 | 99 | 1 | 0 | 41 | 46 | 3 | 3 | 7 |
| Others | 41 | 4 | 93 | 0 | 7 | 15 | 7 | 20 | 10 | 48 |
| Total minor injury | 312 | 34 | 95 | 4 | 1 | 16 | 13 | 29 | 21 | 21 |
| Total | 930 | 100 | 42 | 43 | 15 | 16 | 5 | 16 | 54 | 9 |

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*Percentage of all injuries. †Distribution of AIS for each type of injury. ‡Distribution of body part for each type of injury. §Concussions, contusions, skull fractures. ¶493 fractures and 15 dislocations.

Table 2 Associations between personal and environmental characteristics and nature of injury after a fall from play equipment

| Variable | Number of cases* | | Nature of injury (%) | | Odds ratio† (95% CI) | p Value |
|----------------------|------------------|-------|----------------------|------------------------------|----------------------|---------|
| | n | % | Other (n=312) | Fracture/head injury (n=618) | | |
| Total | 930 | 100.0 | 33.5 | 66.5 | | |
| Type of surface | | | | | | <0.01 |
| Sand | 422 | 45.3 | 39.1 | 60.9 | Ref‡ | |
| Grass | 248 | 26.7 | 25.0 | 75.0 | 1.74 (1.21, 2.52) | |
| Other | 260 | 28.0 | 32.7 | 67.3 | 1.30 (0.93, 1.81) | |
| Type of playground | | | | | | 0.64 |
| Municipal | 519 | 55.8 | 38.2 | 61.8 | Ref | |
| School | 109 | 11.7 | 26.6 | 73.4 | 1.18 (0.71, 1.90) | |
| Daycare | 28 | 3.0 | 46.4 | 53.6 | 1.06 (0.54, 2.08) | |
| Residential | 228 | 24.5 | 25.0 | 75.0 | 1.69 (1.15, 2.47)§ | |
| Others | 46 | 4.9 | 32.6 | 67.4 | 0.76 (0.33, 1.66) | |
| Type of equipment | | | | | | 0.81 |
| Climber | 190 | 20.4 | 31.6 | 68.4 | 1.11 (0.68, 1.80) | |
| Module | 253 | 27.2 | 36.4 | 63.6 | 0.96 (0.61, 1.52) | |
| Swing | 176 | 18.9 | 29.5 | 70.5 | Ref | |
| Slide | 160 | 17.2 | 37.5 | 62.5 | 1.20 (0.73, 1.96) | |
| Others | 151 | 16.2 | 31.8 | 68.2 | 0.92 (0.55, 1.52) | |
| Accident's location¶ | | | | | | <0.01 |
| Island of Montreal | 556 | 59.8 | 59.9 | 40.1 | Ref | |
| Elsewhere | 374 | 40.2 | 23.8 | 76.2 | 1.85 (1.35, 2.50) | |
| Supervision | | | | | | 0.21 |
| Yes | 596 | 64.1 | 36.7 | 63.3 | Ref | |
| No | 334 | 35.9 | 27.8 | 72.2 | 1.23 (0.89, 1.69) | |
| Age (y) | | | | | | <0.01 |
| 1–4 | 351 | 37.7 | 41.6 | 58.4 | Ref | |
| 5–9 | 441 | 47.4 | 26.8 | 73.2 | 1.99 (1.47, 2.74) | |
| 10–14 | 138 | 14.8 | 34.8 | 65.2 | 1.59 (1.01, 2.39) | |
| Sex | | | | | | 0.44 |
| Male | 504 | 54.2 | 32.9 | 67.1 | Ref | |
| Female | 426 | 45.8 | 34.3 | 65.7 | 0.89 (0.67, 1.19) | |
| Playground use | | | | | | 0.07 |
| Rarely | 236 | 25.4 | 25.0 | 75.0 | Ref | |
| Frequently | 694 | 74.6 | 36.5 | 63.5 | 0.72 (0.51, 1.02) | |

*Totals may vary because of missing data. †Adjusted odds ratios (ORa) and 95% confidence intervals (CI) were estimated by the logistic regression model with nature of injury as the dependent variable. The final model includes the following independent variables: type of surface, age, location of the accident, month, number of medical visits for an injury per year, playgrounds' utilisation. Mothers' educational level, mother's tongue, sex, number of children in the family, year of accident, type of equipment, supervision, and type of playground were not kept in the final model. ‡Ref indicates the reference category used to calculate the ORa. §Surface and type of playground were highly correlated. ORa was calculated in removing surface. ¶Proxy for the proximity from the hospitals.

final model. ORa were derived along with their corresponding 95% confidence intervals (CI).

Results

During the two summers, 930 injuries from falls were reported. Table 1 presents the nature and the body part of the injury. It also contains a severity score derived from the AIS. Nearly 12% of all injuries were head injuries, and 55% were fractures. Other injuries included sprains/strains (11%), contusions (11%) and lacerations (8%). More than half of the children sustained an injury to their upper limbs (54%). Overall, 42% of all injuries were rated as AIS 1, 43% as AIS 2, and 15% as AIS 3. Table 2 presents descriptive statistics. The mean age was 5.8 years, and 54% were boys. One child out of four was injured in a residential playground. A module (composite playstructure) was most often involved, followed by climbers, swings, and slides. Approximately 60% of the parents reported being present when the incident occurred.

Almost 27% of injuries were sustained on grass, mostly in residential settings. Among these, 75% were fractures or head injuries, compared with 61% on sand (69% of AIS2–3 were on grass versus 54% on sand, table 3). Correspondingly, residential playgrounds were

associated with a greater proportion of fractures and head injuries (75%) and of AIS2–3 (64%). The adjusted risk of fractures and head injuries and of AIS2–3 injuries was 1.7 times greater on grass than on sand. These injuries were also more likely to happen at home than at public playgrounds although the association was not statistically significant for AIS (ORa=1.29; CI: 0.91, 1.84).

Discussion

This is one of the first epidemiological studies to confirm that grass is not a good protective surface beneath play equipment. A child is more likely to have a head injury or fracture (or an AIS 2–3 injury) when falling on grass compared with sand.

One limitation of this study concerns the choice of paediatric hospitals because children visiting them may be different than those who consult elsewhere. Hence, the proportion of severe injuries and of fractures and head injuries observed in this study may overestimate the proportion that would be found if all of the emergency rooms in Montreal hospitals were included. Furthermore, children from outside of the Island of Montreal tend to go to paediatric hospitals for more severe injuries. Combined with the fact that these children also have more playground equipment at home than children residing elsewhere on the Island, we thought that this could inflate the effects. To verify this, a sub-analysis was performed limited to children from the Island of Montreal. The results were less striking, but in the same direction. In the final model, we controlled for this possible bias by including the accident location.

Other potential biases in this study would have decreased the relation between grass, nature, and severity of the injury. Because misclassification of surfaces by the parent is not associated with injury severity, it would bias the results toward the null given that parents tend to judge unsafe surfaces as safe. It was not possible to adjust for the height of equipment because this information from the parents was not reliable. Nevertheless, elsewhere we have shown that adjustment for height strengthens the association between surface and severity because equipment on sand tends to be taller.⁵

The multivariate analyses performed lent strength to the conclusion by allowing us to control for different personal and environmental covariates, and thus verify that the association between surfaces and nature of injury is independent of other potential confounders. Unfortunately, the number of grass and sand surfaces at home and at public playgrounds did not allow us to verify that the relation between grass, nature, and severity of the injury was the same in each of these two settings, independently. Nor could we control for the way children play at home or at a public playground, although we did control for variables that could be related to this (age, sex, number of children in the family, frequency of use of equipment). Our conclusions are further reinforced by the fact that the results were the same when the models were run separately for 1991

Table 3 Associations between personal and environmental characteristics and severity (AIS) of fall injury from play equipment

| Variable | Number of cases* | | Severity of injury (%) | | Odds ratio† (95% CI) | p Value |
|----------------------|------------------|------|------------------------|-----------------|----------------------|---------|
| | (n=930) | % | AIS 1 (n=387) | AIS 2-3 (n=543) | | |
| Type of surface | | | | | | <0.01 |
| Sand | 422 | 45.3 | 45.7 | 54.3 | Ref‡ | |
| Grass | 248 | 26.7 | 31.5 | 68.5 | 1.68 (1.17, 2.36) | |
| Other | 260 | 28.0 | 44.6 | 55.4 | 1.01 (0.73, 1.39) | |
| Type of playground | | | | | | 0.30 |
| Municipal | 519 | 55.8 | 45.3 | 54.7 | Ref | |
| School | 109 | 11.7 | 31.2 | 68.8 | 1.26 (0.79, 2.02) | |
| Daycare | 28 | 3.0 | 57.1 | 42.9 | 0.65 (0.29, 1.46) | |
| Residential | 228 | 24.5 | 36.0 | 64.0 | 1.29 (0.91, 1.84)§ | |
| Others | 46 | 4.9 | 43.5 | 56.5 | 0.76 (0.33, 1.66) | |
| Type of equipment | | | | | | 0.62 |
| Climber | 190 | 20.4 | 37.9 | 62.1 | 1.19 (0.74, 1.89) | |
| Module | 253 | 27.2 | 41.1 | 58.9 | 0.93 (0.58, 1.48) | |
| Swing | 176 | 18.9 | 42.6 | 57.4 | Ref | |
| Slide | 160 | 17.2 | 47.5 | 52.5 | 1.19 (0.74, 1.89) | |
| Accident's location¶ | | | | | | <0.01 |
| Island of Montreal | 556 | 59.8 | 49.3 | 50.7 | Ref | |
| Elsewhere | 374 | 40.2 | 30.2 | 69.8 | 2.03 (1.51, 2.75) | |
| Supervision | | | | | | 0.03 |
| Yes | 596 | 64.1 | 46.3 | 53.7 | Ref | |
| No | 334 | 35.9 | 33.2 | 66.8 | 1.39 (1.02, 1.89) | |
| Age (y) | | | | | | <0.01 |
| 1-4 | 351 | 37.7 | 51.0 | 49.0 | Ref | |
| 5-9 | 441 | 47.4 | 34.5 | 65.5 | 1.94 (1.43, 2.63) | |
| 10-14 | 138 | 14.8 | 40.6 | 59.4 | 1.74 (1.13, 2.67) | |
| Sex | | | | | | 0.85 |
| Male | 504 | 54.2 | 41.9 | 58.1 | Ref | |
| Female | 426 | 45.8 | 41.3 | 58.7 | 0.97 (0.74, 1.28) | |
| Playground use | | | | | | 0.07 |
| Rarely | 236 | 25.4 | 31.8 | 68.2 | Ref | |
| Frequently | 694 | 74.6 | 45.0 | 55.0 | 0.71 (0.51, 0.98) | |

*Totals may vary because of missing data and to the other category that is not always reported.

†Adjusted odds ratios (ORa) and 95% confidence intervals (CI) were estimated by the logistic regression model with severity of injury as the dependent variable. The final model includes the following independent variables: type of surface, age, location of the accident, month, number of medical visits for an injury per year, playgrounds' utilisation. Mothers' educational level, mother's tongue, sex, number of children in the family, year of accident, type of equipment, supervision, and type of playground were not kept in the final model. ‡Ref indicates the reference category used to calculate the ORa. §Surface and type of playground were highly correlated. ORa was calculated in removing surface. ¶Proxy for the proximity from the hospitals.

and 1995 and with AIS as the outcome variable. These results contrast with those of Sacks and his collaborators,³ but we believe that if they had controlled for height, they would not have considered grass as a safe surface.

A difference was observed between the two models with regard to the risk of fractures and head injuries, and to the risk of AIS2-3 at residential playgrounds when compared with public playgrounds. These results may be partly

KEY POINTS

- Grass should not be considered as a safe surface under play equipment.
- Children sustained more severe injuries in residential playgrounds than in public playgrounds.
- It is recommended to replace grass by sand beneath play equipment.

explained by the fact that it is mainly the head injuries sustained by young children that were rated as AIS1 and that this was more pronounced at home than in public playgrounds. Nevertheless, our results suggest that the risk of having a fracture or head injury is higher at home than at a public playground (ORa= 1.69) and that the risk of having an injury rated as AIS2-3 tends to be larger, although the results were not significant (ORa= 1.29). The use of residential playgrounds has increased since 1991, especially among children aged 1 to 4.⁴ As we have shown that children were exposed to higher risks of fractures and head injuries at home than in public playgrounds, more attention should be given to playground surfacing at home.

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Conflicts of interest : none.

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