

**ABSTRACT**

**Objective:** To assess compliance with current standards of playgrounds where children have sustained a fall-related arm fracture.

**Design, setting and participants:** Between October 2000 and December 2002, a consecutive prospective series of 402 children aged under 13 years who fell from playground equipment and sustained an arm fracture was identified by emergency department staff in five Victorian hospitals. Trained field testers measured playground equipment height, surface type and depth, and surface impact attenuation factors to determine compliance with safety standards.

**Results:** Ninety-eight percent of playgrounds had a recommended type of surface material. The mean surface depth was 11.1 cm (SD, 5.0 cm) and the mean equipment height was 2.04 m (SD, 0.43 m). Although over 85% of playgrounds complied with recommended maximum equipment height and surface impact attenuation characteristics, only 4.7% complied with recommended surface depth.

**Conclusion:** Playgrounds where children have sustained an arm fracture generally comply with all important safety recommendations except surface depth. Playground fall-related arm fracture requires specific countermeasures for prevention, distinct from head injury prevention guidelines.

**METHODS**

**Study population**

A consecutive prospective case series study of playground fall-related arm fractures was conducted from October 2000 to December 2002. Emergency department staff at five participating hospitals in Victoria electronically reviewed medical records weekly to identify cases. Our criteria for selection specified children aged under 13 years; falling from fixed playground equipment; located at school or preschool; and resulting in a fracture of the humerus, radius, ulna, or a combination of these bones. Fracture diagnosis was confirmed by a treating physician, and corresponded to ICD-10-AM codes S42.2, S42.3, S42.4, S52, S62.0, S62.1, S62.8 and T10 as seen on x-ray.

**On-site interviews**

Trained field testers interviewed the children in the playground. Questions aimed to determine the equipment from which the child fell, the equipment height and the playground surface impact location. Child height and weight were measured at interview.

**Field measurements and data analysis**

Field measurements included equipment height and surface type and depth. The maximum height of the equipment...
was measured as the vertical distance from the surface to the highest accessible part of the structure. Surface depth was measured (for loose-fill surfaces only) as the average of three probe readings taken 30 cm apart in a triangle around the surface impact location. If the surface had been modified after the fall, child details were recorded but surface depth and equipment height were excluded.

Peak impact deceleration was measured using a triaxial accelerometer headform (Playground Clearing House MAX G/SI, Phoenixville, Pa) in a standard drop-test procedure. Instrumentation has been previously described and output validated. Headform impact tests were conducted from the maximum height of the equipment. Deceleration/time curves were generated, from which peak impact deceleration and HIC were derived, and the worst outcome of three drop tests was included in the analysis.

As availability of the playground headform was limited, surface impact tests were undertaken in only 50% of playgrounds. Independent t-tests were conducted to detect any significant difference between headform-tested and non-headform-tested groups.

We calculated the mean and standard deviation of each variable measured and determined the proportion of playgrounds complying with Australian playground safety standards.

**Ethics approval**

The study adhered to national ethical guidelines. Informed written consent was obtained from the parents of participants.

## RESULTS

### Participants

There were 624 identified children with playground fall-related arm fracture presenting to the five hospitals during the study period. Of these, 179 (28.7%) were not included in the analysis because their families could not be contacted after five attempts by telephone; 26 (4.2%) and 17 (2.7%), respectively, were from families and schools that declined to participate.

The final series comprised 402 cases (a 64.4% recruitment rate). Participants included 175 boys (43.5%) and 227 girls (56.5%) (for a summary of measurements relating to the group, see Box 3).

### Playground surfaces and equipment height

For the 402 playground fall-related arm fractures investigated, 98.0% occurred on recommended surface material, namely tanbark ($n = 389$), sand ($n = 4$) and rubber ($n = 1$). Eight playgrounds (2.0%) had non-recommended surface...
material: soil \((n = 5)\), grass \((n = 1)\), mat \((n = 1)\) and wood \((n = 1)\).

Playground surface modification between the time of the child’s injury and the time of measurement (mean, 20.6 days; SD, 10.4 days) resulted in 32 cases (8.0%) being excluded from surface depth and equipment height measurements and analyses. Playground equipment height was thus measured in 370 playgrounds (92.0%). Nine playgrounds had surfaces (eg, grass, rubber) whose depth was not measurable, leaving 361 playgrounds (89.8%) for which surface depth could be reported.

Headform impact tests were conducted in 198 of the 402 playgrounds (49.3%). Playgrounds were excluded from impact testing if tests were conducted before the availability of the borrowed playground headform device (46.3%), if playground surfaces were modified before the field test (3.7%), or if the risk of damage to the headform instrument was high (0.7%). There were no significant differences between the headform-tested and non-headform-tested groups in terms of child age \((t = 0.2; P = 0.86)\), child height \((t = 0.4; P = 0.73)\), child weight \((t = 0.4; P = 0.70)\), equipment height \((t = 1.3; P = 0.20)\) and surface depth \((t = 1.8; P = 0.07)\).

Summary results for playground equipment height, surface depth, peak impact deceleration and HIC, where measurable, are presented in Box 3.

Although the recommended surface material was often installed, only 17 playgrounds (4.7%) complied with the standard recommended 20 cm surface depth (Box 4).

Most playgrounds (91.6%) complied with the 2.5 m equipment height recommendation (Box 4). Thirty of the 31 playgrounds (96.8%) that did not comply with equipment height recommendations also did not comply with surface depth recommendations.

Most playgrounds (94.4% and 86.2%, respectively) complied with the recommendations that peak impact deceleration should not exceed 200g and HIC should not exceed 1000 (Box 5). Notably, only 6.7% of playgrounds in this series that failed surface depth tests also failed to conform with peak impact deceleration guidelines (Box 6).

The degree of compliance of each measured variable with current safety standards is summarised in Box 7.

**DISCUSSION**

The major finding of our study was that over 86% of the playgrounds assessed complied with current Australian standards in terms of surface material type, equipment height, and measures of surface impact attenuation (peak impact deceleration and HIC). The study also established that correct surface material was installed in 98% of playgrounds, although surface depth compliance was poor (4.7%). Another study reported 16% surface depth compliance in NSW council playgrounds, and our own previous audit of 176 pieces of school playground equipment revealed only 5.7% surface depth compliance (unpublished data).

Surface depth recommendations are included in the standard as simplified proxy guidelines to compliance with playground surface impact attenuation requirements. However, surface depth alone is not a reliable predictor of surface impact attenuation. Our results indicate that arm fracture often occurs in playgrounds that comply with current safety
standard impact attenuation guidelines. The mean impact attenuation values (peak impact deceleration, 119 g; HIC, 615) were well below the currently recommended limits of 200 g and 1000. This finding implies that current playground safety standards are inadequate to address the risk of arm fracture.

There has been some discussion in Australia and overseas about simplifying the standards for playground equipment by adopting only one of the two measures of surface impact attenuation. However, despite a high correlation between peak impact deceleration and HIC values ($r^2 = 0.92$), reliance on peak impact deceleration measures alone as a critical safety guide may underestimate the risk of playground injury (Box 5). By including specific injury criteria such as HIC, safety standards would define about 8% more playgrounds in this series as non-compliant.

Strengths of our study include the large sample size, the standard protocol under which it was conducted, validated field measures of peak impact deceleration and HIC. This case series reveals new and important observations that emphasise the need to further investigate risk factors for arm fracture in children who fall from playground equipment. Limitations of our study include the fact that it was conducted primarily on tanbark surfacing and related only to falls from static playground equipment. A lack of statistical power precluded any stratification of results by age groups.

Playground fall-related arm fracture requires specific countermeasures for prevention, distinct from head-injury prevention guidelines. We believe that injury criteria more closely related to the risk of arm fracture should be developed and included in revised playground safety standards to complement HIC as a guide to playground safety.

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COMPETING INTERESTS

None identified.

REFERENCES


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