CYP(3)-SP26

Children and Young People Committee

Inquiry into Safel Places to play and Hang out.

Response from Professor J R Sibert of Child Health Cardiff

Introduction

When I was Professor of Child Health at Cardiff University, I led a research team which included Cardiff Council and the Emergency Department in Cardiff on investigating Playground Injuries. This resulted in a number of publications including a literature review (1-5). The key to this work was linking individual injuries at the Emergency Department with the playground, equipment and surface they occurred. We also developed a method of estimating exposure.

Brief Historical Background

Before I go into our research in detail, I would like to give a brief historical background to the use of safety surfaces and safer equipment in playgrounds in the United Kingdom. Public playgrounds form a significant part of the play opportunities for children but of course there is much more to children's play than give. It is not surprising therefore that those involved in children's play have been anxious that playgrounds are as popular and provide as many challenges as possible. Going along with the drive to make public playgrounds as interesting as possible, there was also a drive to make them as safe as possible. This started with concern regarding playground injuries and deaths in the 1970s, particularly following an analysis in Sheffield led by the late Cynthia Illingworth This movement led to the introduction of safety features such as impact absorbing surfaces (IAS), changes in equipment entrapment avoidance, height restrictions and guardrails, and changes in materials used in construction of equipment, and design. These changes led to introduction of standards in Britain, Europe, Australia and the United States. It is important to realise that safety surface were introduced to prevent head injury and not overall injury. They were assessed in biomechanical terms and not by their actual effectiveness in preventing injury.

It is not surprising however, that the drive for more children's play, and the drive for more safety have been seen to be in conflict and perhaps incompatible. This debate has been heightened by a review by Ball (7) for the Health and Safety Executive in the UK, suggesting that expensive safety modifications have minimal effect and are not cost effective in terms of reducing injury episodes to children.

It is important to realise that deaths from playground injuries are now very rare. Work from the USA suggested that strangulation on clothes may be the most common cause of death.

Our Research

Our first paper (1) drew attention to the number of long bone fractures (predominately to the arm) in playgrounds including those with safety surfaces. Our second paper (2) linked injuries, surfaces and equipment looking at overall injuries. This showed that rubberised impact absorbing surfaces were more effective than bark which were more effective than concrete or asphalt. It also showed that 'monkey bars' (horizontal ladders were the least safe piece of equipment. Our third paper (3) demonstrated that playground injuries could be prevented by collaboration between the local authority and health.

Our literature review

We believed that after these pieces of work it was important to focus on the injuries that really matter: head injuries and arm fractures. To this end we reviewed the literature (4) before 2004 together with a companion paper: 'Head Injury and Fracture in Modern Playgrounds' (5). It is very difficult to construct case-control studies to demonstrate the effectiveness of playground surfaces as they were introduced with only mechanical evidence of their value. Nevertheless it is possible to look at the literature before they were introduced and the situation in modern playgrounds now. The literature review (1) looked at papers on playground injuries before 1975 and found three papers from Sheffield (6), London (8) and Australia (9). They demonstrated that before safety surfaces were introduced serious head injuries did occur. On the other hand between the 1992-6 no serious head injuries took place in Cardiff playgrounds. All this suggests that serious playground head injuries are prevented by safety surfaces. In contrast the fracture rate (they are almost all arm fractures) is remarkably constant at about 30%. We therefore believed that safety surfacing is likely to be effective in preventing head injuries and should be continued. Safety surfaces were introduced to prevent head injuries. There is also evidence that safety surfacing has prevented overall injuries. However, it does not seem to protect against fractures of the arm.

The literature since 2004

Since our review the literature has emphasised the difficulty in preventing arm fracture (10, 11, 12). However there is nothing I can find that suggests that head injuries are not prevented by safety surfaces. A very recent paper from Canada (13) has compared injuries to children in playgrounds with granitic sand surfaces and with engineered wood fibre surfaces. No serious head injuries and no fatalities were observed in either group however granitic sand playground surfaces reduce the risk of arm fractures from playground falls when compared with engineered wood fibre surfaces.

This is important work because it confirms that significant head injuries do not occur in modern playgrounds but also holds out the hope that arm fractures might be prevented. Sand traditionally caused concern over dog fouling but clearly now needs to be re-examined.

Conclusions

Although there are still challenges, particularly the prevention of arm fractures, modern playgrounds are safer now than they were 40 years ago. They are still popular with children and mostly provide good play experience for them.

They do not need fall heights of over 4metres, and concrete surfaces to be exciting for children. If they are seen to be safe by parents, they will allow their children to play. This will mean safety for the children and good play experience as well.

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Unique Identifier	16326766
Authors	Fiissel D. Pattison G. Howard A.
Authors Full Name	Fiissel, D. Pattison, G. Howard, A.
Institution	The Hospital for Sick Children, Toronto, Canada.
Title	Severity of **playground** fractures: play equipment versus standing height falls.
Source	Injury Prevention. 11(6):337-9, 2005 Dec.
Abstract	**AIM:** To compare the severity of fractures from **playground** equipment falls to the severity of fractures from standing height falls occurring on the **playground**. **METHODS:** This case control study used data on all children presenting to the Hospital for Sick Children (Toronto) from 1995 to 2002 with a fracture due to a **playground** fall. Cases were children who fell from a height off **playground** equipment. Controls were children who fell from standing height on a **playground**. Fractures were major if they required reduction and minor if they did not. **RESULTS:** Fractures from equipment falls were 3.91 (95% CI 2.76 to 5.54) times more likely to require reduction than were fractures from standing height falls. **CONCLUSIONS:** Major fractures were strongly associated with falls from **playground** equipment, whereas minor fractures came from both play equipment and standing height falls. Efforts to prevent major fractures should target **playground** equipment and the impact absorbing surface beneath it.

Unique Identifier	15805443
Authors	Sherker S. Ozanne-Smith J. Rechnitzer G. Grzebieta R.
Authors Full Name	Sherker, S. Ozanne-Smith, J. Rechnitzer, G. Grzebieta, R.
Institution	NSW Injury Risk Management Research Centre, University of New South Wales, Sydney, NSW 2052, Australia. Shauna.Sherker@unsw.edu.au
Title	Out on a limb: risk factors for arm fracture in **playground** equipment falls.
Source	Injury Prevention. 11(2):120-4, 2005 Apr.
Abstract	**OBJECTIVES:** To investigate and quantify fall height, surface depth, and surface impact attenuation as risk factors for arm fracture in children who fall from **playground** equipment. **DESIGN:** Unmatched case control study. **SETTING:** Five case hospitals and 78 randomly selected control schools. **PARTICIPANTS:** Children aged less than 13 years in Victoria, Australia who fell from school **playground** equipment and landed on their arm. Cases sustained an upper limb fracture and controls had minor or no injury. A total of 402 cases and 283 controls were included. **INTERVENTIONS:** Children were interviewed in the **playground** as soon as possible after their fall. **MAIN OUTCOME MEASURES:** Falls were recreated on site using two validated impact test devices: a headform (measuring peak G and HIC) and a novel anthropometric arm load dummy. Equipment and fall heights, as well as surface depth and substrate were measured. **RESULTS:** Arm fracture risk was greatest for critical equipment heights above 1.5 m (OR 2.39, 95% CI 1.49 to 3.84, p<0.01), and critical fall heights above 1.0 m (OR 2.96, 95% CI 1.71 to 5.15, p<0.01). Peak headform deceleration below 100G was protective (OR 0.67, 95% CI 0.45 to 0.99, p = 0.04). Compliance with 20 cm surface depth recommendation was poor for both cases and controls. **CONCLUSIONS:** Arm fracture-specific criteria should be considered for future standards. These include surface and height conditions where critical headform deceleration is less than 100G. Consideration should also be given to reducing maximum equipment height to 1.5 m. Improved surface depth compliance and, in particular, guidelines for surface maintenance are required.

Unique Identifier	15174986
Authors	Sherker S. Ozanne-Smith J.
Authors Full Name	Sherker, Shauna. Ozanne-Smith, Joan.
Institution	Accident Research Centre, Building 70, Monash University, Melbourne, VIC 3800, Australia. ShaunaSherker@yahoo.com.au
Title	Are current **playground** safety standards adequate for preventing arm fractures?[see comment][erratum appears in Med J Aust. 2004 Nov 15;181(10):532].
Comments	Comment in: Med J Aust. 2005 Jan 3;182(1):46-7; author reply 47; PMID: 15651954
Source	Medical Journal of Australia. 180(11):562-5, 2004 Jun 7.
Local Messages	Held at BMA Library
Abstract	**OBJECTIVE:** To assess compliance with current standards of **playground**s 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. **MAIN OUTCOME MEASURES:** **Playground** compliance with current Australian safety standards. **RESULTS:** Ninety-eight percent of **playground**s 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 **playground**s complied with recommended maximum equipment height and surface impact attenuation characteristics, only 4.7% complied with recommended surface depth. **CONCLUSION:** **Playground**s 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.

Safety of surfaces and equipment for children in playgrounds

Alison Mott, Kim Rolfe, Rosie James, Rupert Evans, Alison Kemp, Frank Dunstan, Kenneth Kemp, Jo Sibert

Summary

Background The safety of playgrounds is important to protect children from injury, but studies are mostly done mainly under laboratory conditions without epidemiological data. We investigated the safety of different playground surfaces, and types and heights of equipment in public playgrounds in the City of Cardiff, UK.

Methods We did a correlational study of 330 children aged between 0 and 14 years. All children were hurt when playing in playgrounds in Cardiff and presented to the Accident and Emergency Department in Cardiff Royal Infirmary during summer (April to September) 1992 and 1993, and the whole of 1994. We studied the children's hospital records to establish the type of injury and interviewed their parents to find out the playground and type of equipment involved. The main outcome measures were the number of children injured whilst playing, and injury rates per observed number of children on different surfaces, types, and heights of equipment.

Findings Children sustained significantly more injuries in playgrounds with concrete surfaces than in those with bark or rubberised surfaces ($p<0·001$). Playgrounds with rubber surfaces had the lowest rate of injury, with a risk half that of bark and a fifth of that of concrete. Bark surfaces were not significantly more protective against arm fractures than concrete. Most injuries were equipment related. Injury risk due to falls from monkey bars (suspended parallel bars or rings between which children swing) was twice that for climbing-frames and seven times that for swings or slides. The height of the equipment correlated significantly with the number of fractures ($p=0·005$) from falls.

Interpretation Rubber or bark surfacing is associated with a low rate of injuries and we support their use in all public playgrounds. Bark alone is insufficient, however, to prevent all injuries, particularly arm fractures. Rubberised impact-absorbing surfaces are safer than bark. We believe that playing on monkey bars increases the risk of injury in playgrounds and that they should generally not be installed. Safety standards should be based on physical and epidemiological data. Our data suggest that the proposed raising of the maximum fall height from 2·5 m to 3·0 m in Europe is worrying.

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Department of Child Health, University of Wales College of Medicine Academic Centre, Llandough Hospital, Penarth, Vale of Glamorgan, CF64 2XX, UK (A Mott MRCPCH, K Rolfe BA, A Kemp FRCPCH, F Dunstan DPhil, K Kemp PhD, Prof J Sibert MD); **Sports and Leisure Department, Cardiff County Council** (R James MA)**; and Accident and Emergency Department, Cardiff Royal Infirmary, Cardiff** (R Evans FRCS)

Correspondence to: Prof Jo Sibert
(e-mail: Sibert@cardiff.ac.uk)

Introduction

Playgrounds were originally developed during the nineteenth century to offer children play opportunities in an increasingly industrialised society.[1] The safety of playgrounds is important, not only for the prevention of injuries, but also to assure families that they are safe places for their children to play. Public playground provision, safety, and maintenance in the UK are largely the responsibility of the local-government councils.[2] Much work has been done to develop safer equipment and surfaces and in producing acceptable saftey standards (BS 5696 and BS 7188).[3] However, these standards have largely been developed in the laboratory[4] and there has been little analysis of real children being injured in real playgrounds.[5]

Impact-absorbing surfaces are a key safety feature. These types of surface were introduced to reduce the severity of head injuries from falls[6] but their effectiveness has been debated and they are costly.[7] Various surfaces are available, including bark and impact-absorbing rubberised surfacing. Information on injuries that children acquire in the playground is vital for those who develop safety standards, produce equipment, and plan playgrounds. Analysis of the effectiveness of these features is particularly timely since European safety standards for playground safety are currently being developed.

In 1992, we began our research into playground injuries with the aim of investigating the correlation between accidents and specific playgrounds, equipment, and surfaces. We found that for the study to be effective we had to develop a close association with the local authority. Therefore, we developed a safety and research partnership with Cardiff City Council. The council has an active policy of playground development, maintenance, and safety.

Our first study described the pattern of injuries on different playground surfaces.[8] Although bark seemed to be protective against head injury, many children sustained arm fractures after falling from playground equipment on to bark surfaces. During this study we realised that to compare risks, we needed to develop a method of measuring exposure of children to playground injuries. Our objective was to assess the effectiveness of different surfaces and equipment in prevention of injuries. We did this by relating children's injuries in public playgrounds to their exposure to injury.

Methods

In this collaborative study between the Department of Child Health and the Sports and Leisure Department of Cardiff County Council, we recorded the surface types of 85 playgrounds and the type and height of equipment. We investigated injuries sustained while playing on swings, slides, climbing-frames, and monkey bars (a series of parallel bars or rings suspended above the ground between which children swing). We identified children aged between 0 and 14 years who in 1994 attended the Accident and Emergency Department of Cardiff Royal Infirmary, the only accident department for Cardiff, with an injury that had occurred in a public playground. We had already collected details of injuries that occurred during the summer (April to September) in 1992 and 1993. We excluded accidents at home, school, or in

	Playground surface				
	Rubber (n=15)	Bark/ rubber (n=5)	Bark (n=47)	Bark/ tarmac (n=3)	Concrete/ tarmac (n=15)
Mean number of children playing	37	34	281	8	29
Total injuries	6	10	90	6	24
Expected number of injuries	13	12	98	3	10
Injuries per mean number of children	0·162	0·294	0·320	0·750	0·828
Risk of injury relative to rubber surface	1·00	1·81 (0·66–4·98)	1·98 (0·87–4·52)	4·63 (1·49–14·4)	5·11 (2·09–12·5)

Table 1: **Total injuries in 1994 related to exposure on different types of surface**

supervised adventure playgrounds. We contacted the parents to identify in which playground and on which equipment the injury happened. Injury details were collected from the Accident and Emergency Department and hospital notes.

Playground inspectors recorded how many children played in each playground throughout the whole of 1994. They visited the playgrounds at random as part of their daily work, at times when the playgrounds were used. Inspections included weekends, school holidays, and evenings during the summer. From the figures they collected, we calculated the mean number of children playing in each playground.

We analysed the protective effect of the various playground surfaces by studying the overall injury data from 1994 and data for different injury types. We calculated the mean number of children that played on each surface from the sum of the mean numbers for playgrounds with that surface. We were then able to estimate the expected number of injuries by giving each surface the same injury risk and to calculate injury risks for each surface per mean number of observed children. We also calculated the risk of each surface relative to the safest (rubber).

To analyse the risk of injury from falls from the equipment, we studied falls from swings, slides, climbing-frames, and monkey bars. We used data from the summers (April to September) of 1992 and 1993, and the whole of 1994 from playgrounds with bark surface only, since this was the surface in the highest number of playgrounds. We assumed that children who are in a playground have equal opportunities of playing on each piece of equipment. Therefore, we assume that there is an equal distribution of children to equipment. We estimated the mean number of children on a particular type of equipment in a particular playground from the mean number of children playing in that playground multiplied by the number of pieces of that type of equipment there. We then used the sum of these figures to calculate the mean number of children playing on any piece of equipment. We compared observed and expected injuries and calculated relative risks.

To investigate the relation between injuries from falls and the maximum fall height of equipment, we looked at equipment in bark-surfaced playgrounds. We measured the maximum fall height of climbing-frames in all bark-surfaced playgrounds, and analysed the relation to the number of fractures arising from falls from this equipment by Poisson regression,[9] taking into account the average amount of use.

Results

There were 85 playgrounds in Cardiff in 1994, with tree bark (conforming to British Standards), impact-absorbing rubberised, or concrete or tarmac surfaces (table 1). 330 children attended the Accident and Emergency Department of the Cardiff Royal Infirmary with a playground injury. Full accident details were obtained for 301 children. The mean and median ages were both 7·4 years (range 1·2–14·9 years); 167 (55·5%) were boys. 48

	Playground surface				
	Rubber	Bark/ rubber	Bark	Bark/ tarmac	Concrete/ tarmac
Fractures					
Observed number	0	6	34	0	4
Expected number	4	4	32	1	3
Concussion					
Observed number	1	0	2	0	5
Expected number	0·8	0·7	5·8	0·1	0·6
Laceration/abrasion					
Observed number	4	2	45	3	15
Expected number	7	6	50	1	5
Other					
Observed number	1	2	9	3	0
Expected number	1·4	1·3	10·9	0·3	1·1

Table 2: **Patterns of injuries on different types of surface in 1994**

(16%) children were admitted to hospital, 44 with a fracture. Only two children were admitted for overnight observation for concussion. Three children were permanently disabled. Most injuries were equipment related: 196 (65%) children fell from equipment, 45 (15%) collided with fixed equipment, 19 (6%) collided with moving eqipment, and ten (3%) children were trapped by or caught in equipment. Only 31 (10%) children had injuries that were not equipment related.

During 1994, playground inspectors collected data on 30 506 children during 3221 visits to the playgrounds in Cardiff. We calculated the mean number of children playing on playgrounds of each surface (table 1). In 1994, 152 children were injured and we obtained full details for 136 of them. We confirmed the high numbers of arm fractures due to falling from equipment that we found in our first study;[7] all but three fractures were of the arm. Actual numbers of injuries for 1994 in playgrounds of each surface are shown in table 1. We also show the expected number of injuries if each surface had the same injury risk with allowance for exposure. χ^2 analysis[10] showed that children had significantly more injuries on concrete surfaces than bark or rubberised surfaces ($p<0·001$). Analysis of relative risks for surfaces showed that injury risks on rubberised surfaces are half that of bark and a fifth of the risk on concrete.

We show in table 2 the observed and expected numbers of different types of injuries on different surfaces. Many of the expected numbers are small and not much can be inferred from them, but there are significant differences between the observed and expected numbers of lacerations or abrasions ($p<0·001$); the observed number for concrete and tarmac was three times the expected number. Bark was not protective against fractures, but our results suggested that rubber might be.

We calculated injury risks on swings, slides, climbing-frames, and monkey bars on bark surfaces (table 3). The differences in the number of fractures between different pieces of equipment were significant ($p=0·001$).[9] The risk

Type of injury	Type of equipment			
	Slide	Swing	Climbing-frame	Monkey bars
Observed fractures	8	9	30	23
Expected fractures	23·4	19·6	20·2	6·8
Observed total injuries	16	17	48	35
Expected total injuries	39	32	34	11
Relative risk of injury	1·00	1·27 (0·64–2·51)	3·47 (1·97–6·11)	7·49 (4·14–13·5)

Table 3: **Comparison of fractures and injuries from falls on to bark surfaces according to equipment (1992–94)**

Height (cm)	Number of climbing-frames	Estimated use of equipment	Observed number of fractures	Expected number of fractures	Injury per mean number of children
71–90	1	11	0	0·8	0
91–110	4	35	0	2·7	0
111–130	5	50	0	3·8	0
131–150	9	43	1	3·3	0·02
151–170	11	53	8	4·0	0·15
171–190	10	94	10	7·2	0·11
191–210	8	51	5	3·9	0·10
211–230	3	17	1	1·3	0·06
231–250	4	39	5	3·0	0·13

Table 4: **Fracture rate and height of climbing-frames on bark surfaces (1992–94)**

of a child receiving an injury or a fracture due to falls from monkey bars was twice that for climbing-frames and seven times that for swings or slides.

Table 4 shows a summary of the heights of falls from equipment and the numbers of fractures caused. Poisson regression[8] showed a significant linear relation between the height of the equipment and the number of fractures (p=0·005). There was no evidence of non-linearty.

Discussion

The importance of reliable estimates of exposure in the analysis of playground accident data cannot be overemphasised. One bark-surfaced playground had a high rate of injuries, but exposure data showed that in 1994, this playground was used at least five times more frequently than the other playgrounds with bark surfaces. Our method of measuring exposure of children to injuries relies on the observations of the people who work in the playgrounds. Results should, therefore, be reproducible and free from bias. We also found that a partnership between the local council and the Department of Child Health was essential in this work. We have developed a surveillance system in which we send information on injuries to the council and they inspect the playground and make changes if necessary.[11]

The safety of children in public playgrounds is a complex interaction between several factors. We believe the type of surfacing, the type of equipment, and the height of equipment are the most important.

We have shown that some types of surfacing are more protective against injuries to children in playgrounds. Installation of these surfaces alone is insufficient, however, to prevent all injuries to children. We found that children are not protected against arm fractures by bark, surfaces. Our study also suggests that a rubberised impact-absorbing surface is safer than bark. The distribution of rubberised surfaces is random throughout Cardiff and demographic characteristics are therefore unlikely to bias this result. We hope that this information will be helpful to local councils in making decisions about playground surfaces. Our findings support the introduction of impact-absorbing surfaces. Maintenance and depth are clearly important factors in the effectiveness of bark surfaces. Cardiff County Council have a policy of regular maintenance and inspection to keep bark to a depth and quality according to current British Standards. Bark surfaces are less expensive to install than rubberised impact-absorbing surfaces, but they need much more maintenance.

Most injuries were equipment related. Surface types cannot be considered in isolation from equipment. When exposure is taken into account the risks to children receiving injuries on different pieces of equipment differ. The probability of receiving an injury when playing on monkey bars was twice that of a climbing-frame and seven times that of a swing or slide. We therefore identified monkey bars as having an especially high risk, probably because of the upper-body strength and coordination they require, and believe that they should not be generally provided.

Chalmers and colleagues[12] from New Zealand clearly showed that the risk of injury was significantly increased at heights of over 1·5 m. Our analysis of maximum fall heights confirms these findings. The difference may be caused by the forces involved in falls from higher than 1·5 m. Older children may also feel that play is less dangerous over a safety surface.

Children will always have falls on playgrounds since exploration and testing of limits are a natural part of child development. Playgrounds need to remain exciting and challenging to children since they are far safer places to play than alternatives such as the roads. Playground design should balance play value with safety issues. Safety standards in playgrounds are important; they are currently developed from physical data gathered under laboratory conditions only, and not from epidemiological data. The separate roles of the surface type, the type of equipment, and the height of equipment should be taken into account. Since the height of equipment is a significant factor in the risk of fracture, we are particularly worried by the suggestion that in the European Standards the maximum fall height should be raised from 2·5 to 3·0 m.

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Papers

Preventing injuries in public playgrounds through partnership between health services and local authority: community intervention study

J R Sibert, *professor of community child health* [a], **Alison Mott**, *consultant paediatrician (community child health)* [a], **Kim Rolfe**, *research assistant* [a], **Rosie James**, *principal landscape officer* [b], **Rupert Evans**, *consultant* [c], **Alison Kemp**, *senior lecturer in community child health* [a], **F D J Dunstan**, *senior lecturer in medical statistics* [a].

[a] Department of Child Health, University of Wales College of Medicine, Academic Centre, Llandough Hospital, Penarth, Vale of Glamorgan CF64 2XX, [b] Sports and Leisure Department, Cardiff County Council, Cardiff CF14 4EP, [c] Accident and Emergency Department, University Hospital of Wales, Cardiff CF4 4XW

Correspondence to Professor Sibert sibert@cardiff.ac.uk

Public playgrounds are important for children's play and development. Safety is a prime concern not only to prevent injuries but also because families need the assurance that it is safe for their children to play.[1] One way of improving safety is for health services and local authorities to form a partnership in the surveillance of injuries and the making of improvements. We report the results of such a partnership in Cardiff. [2 3]

Participants, methods, and results

Children injured in public playgrounds in Cardiff were identified from the accident and emergency department and linked to the playground, equipment, and surface. We estimated exposure of children to injuries from the numbers of children recorded to be playing in individual playgrounds by inspectors visiting them at random as part of their work.[3] From this information we calculated injury rates per observed child.

In June and July 1995 the council made several changes to its largest playgrounds on the basis of our surveillance programme. [2 3] A greater depth of bark (600 mm instead of 300 mm) was introduced in Roath Park and the four other large playgrounds in the north area of the council's sports and leisure department. This was because of the pattern of arm fractures from falls we had found in our previous studies. [2 3] In Roath Park monkey bars (overhead horizontal ladders) were replaced by a rope climbing frame. This was because the fracture rate for monkey bars was twice that for other climbing frames. We used as controls the 14 playgrounds surfaced with bark and the four surfaced with rubber in the two other areas in Cardiff (west and south east) where the council had not made any changes during 1994-6.

We assumed a Poisson model for the injury rate, and we compared injuries and the injury rate per observed child in the 18 months before and after the changes were implemented and between the three groups of playgrounds. Exposure data for the control playgrounds in the second 18 months were patchy, and we have assumed that usage was unchanged. Data from the playgrounds with good exposure data showed that usage remained roughly constant throughout the study, and we have therefore assumed this where data were limited.

The changes we made did not lessen the popularity of the playgrounds, and no injuries were recorded for the rope climbing frame. The table shows that the injury rate per observed child was significantly reduced in the five playgrounds where changes had been made. There were also significant differences when Roath Park was taken on its own but not with the four playgrounds with changes to bark depth alone.

View this table: [in this window] [in a new window]	Injuries and injury rates per observed child in playgrounds in Cardiff

In assessing our surveillance system we compared for 1994-6 the children ascertained by us with those reported to the council. In 1994, 152 injuries were recorded by our surveillance system and 33 by the council's reporting system. In 1995 the numbers were respectively 113 and 12 and in 1996, 112 and 20. There are clear differences.

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We believe that our surveillance programme has contributed to playground development and safety in Cardiff. We were concerned that replacement of monkey bars and the introduction of other safety measures would make playgrounds less popular, but this was not the case. This surveillance programme and partnership is comparatively simple to apply. It does not need expensive resources, and it could be introduced widely.[4]

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Contributors: JRS was concerned with planning, supervision, and analysis and is guarantor for the study. AM was concerned with planning, supervision, and analysis. KR was responsible for managing the database. RJ obtained data on exposure and liaised with Cardiff County Council. RE liaised with the accident and emergency department. FDJD was responsible for statistical analysis. Kenneth Kemp, emeritus professor and honorary senior research associate, was responsible for statistical analysis at the beginning of our work on playground injuries.

Footnotes

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Competing interests: In 1998, after the period of this study, we had limited funding for our surveillance programme from playground equipment manufacturer (Hags Play, Sturminster Newton, Dorset).

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Head injury and limb fracture in modern playgrounds

C Norton, K Rolfe, S Morris, R Evans, R James, M D Jones, C Cory, F Dunstan and J R Sibert

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SHORT REPORT

Head injury and limb fracture in modern playgrounds

C Norton, K Rolfe, S Morris, R Evans, R James, M D Jones, C Cory, F Dunstan, J R Sibert

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There were no serious head injuries in modern Cardiff municipal playgrounds with safety surfaces over five years injury surveillance. The literature suggests serious head injuries did occur before the introduction of safety surfaces.

Playground standards have been introduced throughout the Western world to promote safe play for children. They advise on the design, dimensions, and layout of playgrounds, including the use of impact absorbing surfaces. These surfaces were introduced primarily to reduce head injury; however, there has been controversy on their effectiveness. Ball has argued that they have not reduced injury,[1] and raises doubts that their cost is justified. However, there is evidence that overall injuries are less frequent on safety surfaces.[2] The majority of the literature has analysed playground injuries as a whole; however, it is head injury and fracture that really should concern us, as they are the injuries that might cause permanent disability and most morbidity to children. We are therefore presenting information on five years detailed surveillance of playground injury, focusing on head injuries and fractures. This has been achieved by the partnership between a University Department of Child Health, the Emergency Department, and the Council's Parks Service.[2 3]

METHODS AND RESULTS

We studied any child 0–14 years presenting to the Cardiff Royal Infirmary Emergency Department during 1994–98, whose location of injury was coded to a public playground in Cardiff. We correlated information on the injury and its location and mechanism with information on equipment and surface recorded by the Parks Service. We have described the injury surveillance scheme in detail in our previous work.[2 3] Concrete and tarmac surfaces in Cardiff playgrounds were phased out from 1994–95; this paper therefore focuses on head injuries and fractures to children on the modern playgrounds. These modern playgrounds all had bark or rubber impact absorbing surfaces with modern equipment and had maximum fall heights of less than 2.5 metres. We have confirmed fractures by clinical examination and interpretation of radiographs. We have compared these with similar injuries from all causes to Cardiff children in 1996–98 from the All Wales Injury Surveillance System.

We recorded a total of 473 children injured in Cardiff playgrounds with modern surfaces connected with equipment in the five years of the study (incidence 145 (95% CI 131 to 159) per 100 000) (table 1). Of these, 291 were from falls from equipment onto modern surfaces. A further 69 children were injured on tarmac or concrete playgrounds, mainly at the start of the study; they were not analysed in this paper. The mean age of children injured on the playgrounds was 6.96 years (range 11 months to 14 years); 57% of injuries were to boys. There were no deaths.

There were no children with skull fractures or needing more than overnight admissions for observation for head injury. Only two children were admitted overnight for observation because of head injury from falls onto modern surfaces: one bark and one rubber. They made a full recovery. The incidence of head injury needing overnight admission from playground falls to a modern surface is 0.6 (95% CI 0 to 1.4) per 100 000. Serious head injury is therefore very rare on modern playgrounds.

In contrast there were 146 limb fractures on playgrounds with modern surfaces (incidence 45 (95% CI 38 to 52) per 100 000). The majority were to the upper limb (137); this number represents 7% of all arm fractures to Cardiff children. Of these, the majority (128) were due to falls onto surfaces: mainly from climbing frames or monkey bars. Of the 146 children with fractures, a third (47) required hospital admission, mainly (42) for surgical intervention (mainly manipulation under anaesthesia). Table 2 shows details of the fractures.

DISCUSSION

Municipal playground injuries only represent a small proportion of the huge numbers of children attending the

Table 1 Injuries on modern playgrounds

Type of injury	Total	Admissions	MUA	Incidence per 100000/year (95% CI)
Playground injuries (1994–98) (equipment on modern surfaces)	473			145 (131 to 159)
Playground injuries (1994–98) (equipment on modern surfaces, falls onto surface only)	291			89 (79 to 99)
Playground head injury admission (1994–98) (equipment on modern surfaces)	2 (both falls)			0.6 (0 to 1.4)
Playground fractures (1994–98) (equipment on modern surfaces)	146	47	42	45 (38 to 52)
Playground fractures (1994–98) (equipment on modern surfaces, falls onto surface only)	131	42	39	40 (33 to 47)
Playground arm fractures (1994–98) (equipment on modern surfaces)	137	43	41	42 (35 to 49)
Playground arm fractures (1994–98) (equipment on modern surfaces, falls onto surface only)	128	40	38	39 (32 to 46)

MUA, manipulation under anaesthesia.

Table 2 Site and number of fractures

Site	Number	Breakdown	Number
Hand	4 (3%)		
Wrist	75 (51%)		
		Radius alone (2 bilateral)	39
		Radius + ulna	35
		Ulna	1
Forearm	13 (9%)	Radius + ulna	11
Elbow	29 (20%)		
		Humerus	23
		Radius	4
		Ulna	2
Upper arm	3 (2%)	Humerus	3
Shoulder	13 (9%)		
		Clavicle	7
		Humerus	6
Nose	3 (2%)		
Lower limb	6 (4%)		
		Tibia	3
		Tibia and fibula	2
		Metatarsal	1

accident department in a year. Head injury is now very rare in modern playgrounds. The question is whether this has reduced since the introduction of safety features such as safety surfacing.

The evidence pre-1985 when safety surfaces were initially introduced is sparse, so any quantitative study is difficult. When we systematically searched the literature we found three case series, which gave enough detail for qualitative analysis. The detailed descriptions[4–6] in these papers that we have identified suggest that before the introduction of standards and safety surfaces there were serious head injuries. For instance, there was a sixfold greater chance of concussion and the severity of head injury was greater.[4] This is what was intended by the introduction of safety surfacing. However, the proportion of injuries due to arm fractures is unchanged; they were a problem before and are a problem now in modernised playgrounds.

There are biomechanical reasons why safety surfaces may not protect against arm fracture. Experimental arm models suggest that the impact absorbing surfaces may be useful in attenuating forces from impacts involving falls from a standing height. However, in higher falls, such as falls from equipment in playgrounds, the surface is not successfully attenuating all of the force components, which result in fracture.[7]

We believe we should now develop methods for overall playground safety, not only to prevent head injury but also to reduce arm fractures. Playgrounds offer wonderful developmental opportunities and are fun for children. Severe head injuries are now rare on modern playgrounds and the abandonment of safety surfacing may result in further significant head injuries. We now should wish to reduce fracture rates by developing surfaces that protect against head injury and fracture while ensuring that playgrounds remain places in which children want to play.

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Authors' affiliations

C Norton, K Rolfe, S Morris, F Dunstan, J R Sibert, R Evans, Accident and Emergency Department, Cardiff and Vale NHS Trust, UK
R James, Highways and Parks Service, Cardiff County Council, UK
M D Jones, C Cory, Medical Engineering Group, Cardiff University, UK

Correspondence to: Prof. J R Sibert, Department of Child Health, University of Wales College of Medicine, Llandough Hospital, Penarth CF64 2XX, UK; sibert@cardiff.ac.uk

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Playground injuries to children

C Norton, J Nixon and J R Sibert

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Injury

Playground injuries to children

C Norton, J Nixon, J R Sibert

Play value, safety, or both

Play for children has never been more important, particularly as we now know how vital exercise is in promoting health and preventing obesity, both in childhood and also into adult life. Play is also important in establishing social patterns of behaviour that allow children to react to their peers. Public playgrounds form a significant part of the play opportunities for children. It is not surprising therefore that those involved in children's play have been anxious that playgrounds are as popular and provide as many challenges as possible.

Going along with the drive to make public playgrounds as interesting as possible, there was also a drive to make them as safe as possible. This started with concern regarding playground injuries and deaths in the 1970s, particularly following an analysis in Sheffield led by the late Cynthia Illingworth.[1] This movement led to the introduction of safety features such as impact absorbing surfaces (IAS), changes in equipment entrapment avoidance, height restrictions and guardrails, and changes in materials used in construction of equipment, and design. These changes led to introduction of standards in Britain,[2] Europe (EN 1176 and 1177),[3] and Australia.[4] In the United States, the drive towards safety has been led by the Consumer Product Safety Commission.[5]

It is not surprising however, that the drive for more children's play, and the drive for more safety have been seen to be in conflict and perhaps incompatible. This debate has been heightened by a recent review by Ball,[6] for the Health and Safety Executive in the UK, suggesting that expensive safety modifications have minimal effect and are not cost effective in terms of reducing injury episodes to children.

This article will attempt to answer this dilemma: what evidence is there to suggest that playground safety features work, and are they worthwhile in preventing serious injuries? We also would like to review the research agenda to improve playground safety. Much of the literature on injuries to children in playgrounds has included minor injuries such as abrasions and lacerations; however, the main injuries of concern are limb fracture and head injury. We will pay particular consideration to them.

REVIEW OF THE LITERATURE

We have reviewed the literature on playground injury using the approach of a systematic review. We had a clear search strategy focusing on injuries that actually occurred rather than playground characteristics that might in theory cause injury. The detail of the search strategy is included in the Appendix. Papers that did not include injury data and referred to risk or compliance with regulations were excluded. This literature contains only one intervention study[7] and only one randomised control trial,[8] which is on a method of safety promotion in schools to promote safe playgrounds and not on actual injuries. Our analysis of the evidence therefore has to be largely descriptive.

We identified 37 reports on playground related injury and death. However, some of these were either review articles with no new data or had purely descriptive data. Details of the papers we have relied on are shown in tables 1–5. We have included one interventional study,[7] three correlational studies,[9–11] and five case control studies.[12–16]

The majority of the case series identified did not fulfil the criteria for inclusion in our analysis. The studies were generally non-consecutive case series that did not provide information on a range of factors that would influence the predicted profile of injury. However the descriptive detail included within some of these papers provides a valuable historical perspective when considering the impact of modern safety measures. All the papers that provide some evidence are included in tables1–5: both prior to 1985,[1 17–21] when safety surfacing was introduced, and after.[2 22–33] We are also including reference to a recent detailed population based analysis of playground injuries.[34]

WHAT INJURIES OCCUR?

FRACTURES

Fractures remain among the most common reported fall related injury across the range of reports that date from 1974 to 2001 (tables 1–5). This is despite wide variations in equipment, fall surface, and height of fall. Upper limb fractures are most common; however few studies provide detailed fracture analysis. Ball reports that 71% of fractures were to the upper limb:[22] other studies showed even more fractures of this type. A study by Waltzman and colleagues,[31] looking solely at fall injuries from monkey bars or jungle gyms reported that supracondylar humeral fractures accounted for 40% of upper limb fractures. This high percentage may reflect the equipment type, height of fall, or the age of the child. Information was not available on surfacing, but the authors concluded that surface did not influence injury type.

Proximal fracture appears more common in younger children.[25 30 32] The available literature does not inform with regard to the influence of neurodevelopmental status or the interaction between height of fall, type of surface, and fracture type. Lower limb fracture is uncommon. The historical case series by Rivers and colleagues,[17] published in 1978, is unusual in that 60% recorded fractures were to the lower limb. This was a study of hospital admissions, however.

Table 1 Intervention study

Title and author	Population	Method of data collection	Conclusions
Sibert *et al.* Preventing injuries in public playgrounds through partnership: a community intervention study. 1999[7]	A&E attendance for playground injury children 0–14 years. Cases (parks with increased depth bark and monkey bars removed)/control (parks unmodified)	A&E codes. Questionnaire. Parks staff recorded park and equipment use.	Significant ($p<0.001$) reduction in injury rate after removing monkey bars and increasing depth of bark beneath equipment.

Table 2 Correlational studies

Title and author	Population	Method of data collection	Conclusions
Sosin D. Surface specific fall injury rates on Utah school playgrounds. 1993[9]	157 Utah elementary schools, kindergarten to grade 6.	School injury reports. Enrolment data. Equipment data from playground inspection.	Asphalt surfaces associated with increased risk of total injury.
Mott A *et al.* Safety of surfaces and equipment for children in playgrounds. 1997[10]	A&E attendance for playground injury. 0–14 years. Full details 301.	A&E codes. Questionnaire. Park staff recorded playground equipment use. Detailed survey of equipment.	Significant increase ($p<0.001$) in total injuries on concrete relative to bark or rubber. Surface, equipment and height influence injury rates.
Laforest *et al.* Surface characteristics, equipment height, and the occurrence and severity of playground injuries. 2001[11]	185 injuries on inspected playgrounds.	Presentations to A&E in Montreal. Measurements of height and energy absorption of surface.	The risk of injury was three times greater than for g level lower than 150. Injuries were 2.56 times more likely to occur on equipment higher than 2 m compared with equipment lower than 1.5 m.

Table 3 Case-control studies

Title and author	Population	Method of data collection	Conclusions
Chalmers D. Height and surfacing as risk factors for injury in falls from playground equipment. 1996[12]	110 cases playground injuries requiring medical attention. 190 controls—fallen from equipment but no medical attention required.	School staff/hospital records. Interview with child/parents Site visits	The risk of injury increased with heights greater than 1.5 m (OR 4.14) and with non-IAS (OR 2.28). Falls from non-compliant equipment increased risk of injury.
Mowat DA *et al.* Case control study of risk factors for playground injuries among children in Kingston and area. 1998[13]	45 cases A&E attendance with playground injury. Age/sex matched controls non-injury and non-playground injury.	CHIRPP surveillance programme. Telephone interview. Safety audit data/hazard identification.	Injury was associated with inappropriate surfaces (OR 21), appropriate surface of inadequate depth (OR 18.2) and inadequate guard rails (OR 6.7).
Macarthur C *et al.* Risk factors for severe injuries associated with falls from playground equipment. 2000[15]	A&E/Admissions Toronto Hospital for Sick Children after fall from playground equipment. 18 mth–14 years	Hospital records. CHIRPP. Telephone interview. Site visit.	Falls from >1.5 m had a 2-fold increased injury risk. As most children fell onto modern surfaces the role of surface was not evaluated.
Laforest *et al.* Severity of fall injuries on sand or grass in playgrounds. 2000[14]	930 children 1–14 y attending 2 A&E units after falling from play equipment.	A&E database. Telephone questionnaire. (91%) response.	Grass is not a safe surface for play equipment. The adjusted risk of an IAS >2–3 was 1.7 times higher on grass than sand.
Petridou *et al.* Injuries in public and private playgrounds: the relative contribution of structural, equipment and human factors. 2002[16]	777 injuries in public and private playgrounds in Athens. Public playgrounds have more equipment, usually of greater height, with less resilient surfaces.	Injury surveillance in the Accident Department.	2.2 times higher risk for an injury in public than in private playgrounds (95% confidence interval 1.61–3.07). With eight times higher odds for concussion.

Table 4 Case series prior to 1985 (and modernisation)

Title and author	Population	Method of data collection	Conclusions
Illingworth *et al.* Injuries caused by playground equipment. 1975[1]	200 Non-sequential attendances to Sheffield Children's A&E.	Proforma completed. Injury graded.	Narrative study of the injury profile seen on playgrounds. Fractures accounted for 26.5% total injury; this included 5 skull fractures. 12 children had concussion
Rivers R *et al.* Falls from equipment as a cause of playground injury. 1978.[17]	Trauma admissions to UCH in London.	Note review and questionnaire.	40 cases described including 29 head injuries. These were severe with 3 fractures and 8 LOC. Severe head injury associated with non-IAS.
Frost J. Making playgrounds safe for children. 1979[18]	USA.	NEISS data.	Discussion re playground safety regulations.
Oliver T *et al.* Playground equipment and accidents. 1981[19]	Northern Sydney. Children 2–12 years. Limited data on 162 injuries.	Surveys of 7 A&E units.	Falls to hard ground were identified as the prime mechanism of injury. 24% injuries were fractures, these comprised skull and limb fractures.
Christensen S. Accidents with playground equipment 3. 1982[20]	A&E attendance Aarhus. 1–14 years.	Questionnaire A&E attendance Municipal hospitals in Aarhus.	466 children. Injury severity increased with increasing fall height. The available surface should influence the maximum fall height.
Boyce W. Epidemiology of injuries in a large urban school district. 1984.[21]	Tuscon school district.	School nurse data survey.	Playground injuries are relatively severe when compared to all injuries relating to sports and leisure equipment use. Younger children more likely to be injured on playgrounds.

Table 5 Case series after 1985

Title and author	Population	Method of data collection	Conclusions
Ball D. Playground injuries: a scientific appraisal of popular concerns. 1991[22]	13 A&E units in England & Wales.	A&E data LASS.	Total of 1812 cases recorded. Fractures accounted for 16.5% injuries, concussion for 1.4%. Playground injuries are relatively uncommon and certain safety measures may not be justifiable on cost terms.
Edwards D. Tarzan swings. A dangerous new epidemic. 1991.[23]	A&E attendance Sheffield.	Questionnaire.	29 children with fractures, 90% to the upper limb. Homemade rope swings are associated with serious fractures.
Bond M. The risk of childhood injury on Boston's playground equipment and surfaces. 1993[24]	Playgrounds in Boston. 47 in final sample.	Single observer site visit/checklist.	Boston's playgrounds are not adequately maintained or designed to reduce clear hazards.
Mott A *et al*. Patterns of injuries to children on public playgrounds. 1994.[25]	A&E attendances, 0–14 years, Cardiff UK.	Questionnaire. Playground survey. Playground inspectors recorded utilisation.	Fewer injuries overall than predicted on modern surfaces (not statistically significant). The profile of injury differed between surfaces.
Briss P *et al*. Injuries from falls on playgrounds. Effects of day care centre regulation and enforcement. 1994.[26]	Day care centres across USA. Under 5s.	Probability sample. Telephone survey.	Injury rates lower on optimal but not on potentially resilient surfaces. The benefit of optimal surfaces increases with increasing height.
Lillis K. Playground injuries in children. 1997.[27]	CHIRRP data. Sample A&E units	CHIRRP data extraction.	289 injuries, fractures accounted for 28% and concussion for 3%. Climbing frame injuries accounted for 2/3 hospital admissions, most with UL fracture. Numbers were insufficient to comment on effect of surface (and no height data).
Mack M. A descriptive analysis of children's playground injuries in the USA. 1990–94[28]	Neiss data. 90 emergency units in USA.	Neiss database samples 90 A&E units and produces estimates.	Neiss playground injury statistics can identify how and where children are injured, increase understanding and guide attempts to decrease injuries.
Mayr J. Playground accidents. 1995.[29]	1–15 years attending Dept Paediatric Surgery.	Postal questionnaire (28% replied = 103).	Low response rate but 31% injuries were fractures or concussions, most on non-IAS.
Chalmers D, Playground injury: the kids are still falling for it. 1999[30]	Hospital admissions in NZ.	School surveys 1997. NZ health information service statistical data.	Trend for increased reporting of minor injuries. Fewer serious injuries seen on modern surfaces.
Waltzman M *et al*. Monkey Bar injuries. Complications of play. 1999.[31]	Paed admission related to monkey bar falls to Boston trauma centre. Range 20 mth to 12 years.	Retrospective chart review. Telephone survey.	High percentage of fractures (61%) reported. The majority were upper limb with supracondylar fractures accounting for 40% total. Fracture type was age dependent. Children under 4 more likely to sustain long bone fracture. Surface did not influence injury type but no data on height.
Bernardo LM. Playground injuries in children. A review and Pennsylvania trauma centre experience. 2001[32]	Admissions to Pennsylvania trauma centres.	Proforma.	Nurses can advocate for playground safety.
CPSC Playground Injuries treated in US hospital emergency rooms. 2001[33]	Admissions to emergency rooms.	Information direct from emergency rooms.	Typical example of a yearly publication.
Ball D. Playgrounds: risks, benefits and choices. Contract research report. 426/2002. Health and safety Executive 2002	Presentations to LASS from a selection of Accident Departments.	From LASS Data Department of Trade and Industry.	Information 1988–98.

WHAT INJURIES OCCUR? HEAD INJURY

Severe head injury resulting in skull fracture, intracranial haemorrhage, or neurological disturbance requiring admission to hospital is rare on modern playgrounds.[34] Impact absorbing surfaces were introduced to prevent head injury. Earlier case series before the introduction of these surfaces make clear narrative reference to complex skull fractures and intracranial injury. The paper by Cynthia Illingworth and her colleagues in 1975[1] analysed 200 non-consecutive presentations to an accident department. In this Sheffield study, given that a child was injured in a playground, there was a 6% chance of a playground injury resulting in skull fracture or concussion. There are no clear definitions of the severity of head injury in this paper, but there are written descriptions of injuries. These include ''an extensive occipital fracture with loss of consciousness'', ''a drowsy girl with a large fracture of the parietal bone'', ''two severe skull fractures'' and ''a serious injury with a fracture of the occiput''.

Rivers and colleagues[17] described 40 children admitted to hospital (University College Hospital in London) between 1974 and 1977 with playground related injury. This was a study of hospital admissions however, which may have influenced the fractures recorded. The majority (85%) of injuries resulted from falls and the majority of these (26 of 27 where surface was recorded) were on to concrete, tarmac, or packed earth. Twenty nine of these children had head injuries, of which eight children were unconscious, three had skull fracture, and three had neurological symptoms lasting more than 48 hours.

Oliver and colleagues[19] surveyed playground related A&E attendances between 1978 and 1979. This paper contains limited data on 162 injuries. Falls to hard ground were identified as the prime mechanism of injury. Nearly a quarter (24%) of the injuries were skull and limb fractures. Additional information on fracture type was limited to three brief case histories describing two severe skull fractures and a humeral fracture, all requiring hospital admission.

All this suggests that before the introduction of safety features there were definite serious head injuries. The definition of concussion or head injury is not clear in many of the series in our review and therefore definite conclusions are difficult to draw. However, it does appear that serious head injuries are rare on modern surfaces.

RISK WITH SURFACES

A number of studies have linked overall injury rates and surface. One correlational study that looked at overall injuries on modern surfaces and tarmac/concrete[10] reported 330 children aged 1–14 injured on public playgrounds. It found that rubber playgrounds had half the risk of bark and a fifth of that of concrete ($p<0.001$). Chalmers[12] found similar results; the odds of being injured in a fall on a non impact absorbing surface was 2.28 times that of a fall onto an impact absorbing surface. Laforest and colleagues,[14] comparing sand and grass, found that the adjusted risk of injury was 1.7 times more likely on grass relative to sand. Mowat and colleagues,[13] again looking at overall injuries in a case-control study found that multivariate analysis showed a strong association between injuries and use of inappropriate surfacing; Sosin[9] found that the injury rate on asphalt was six times that on sand.

Therefore, if overall injuries are considered, there are significant differences between impact absorbing surfaces and harder surfaces such as tarmac, concrete, or grass. However, what is the situation with fractures? Macarthur and colleagues,[15] in a case-control study, compared severe (mainly fractures) and minor injuries (mainly facial lacerations). There were no significant differences between the surfaces. Similarly bark surfaces were not significantly protective of arm fractures relative to concrete in other studies.[10] The conclusion that safety surfaces are ineffective in preventing arm fractures is also confirmed by the lack of improvement in the proportion of fractures in playground injury surveillance with time.

There are biomechanical reasons why safety surfaces may not protect against arm fracture. Experimental models suggest that the current surfaces may be useful in attenuating forces from impacts involving falls from a standing height. However, in higher falls, such as falls from equipment in playgrounds, the surface is not successfully attenuating all of the force components, which result in fracture.[35]

RISK WITH HEIGHT

The relation between height of fall and injury has been confirmed by a number of studies. Macarthur and colleagues[15] found significant difference in height between severe and minor injuries. Briss and colleagues found injury rates significantly increased with height of the tallest piece of equipment on the playground.[26] Chalmers' work[12] and the work of Mott and colleagues,[10] found that heights below 1.5 metres were protective. Children injured in falls from playground equipment will be more likely to have fallen from greater heights than children with minor injuries (or no injuries).

There have been few studies looking at height of equipment and injuries to children in playgrounds. There are real research questions, in particular establishing whether the increased heights at 4 metres in the European standards really do present increased risks to children.

RISKS WITH EQUIPMENT

There have been considerable improvements in the design of playground equipment over the years. Swings, for instance, have had impact absorbing seats, and ideally fences to prevent children running into them. This has resulted in swings being among the safest pieces of equipment in the playground,[10] whereas in 1976 a swing was reported to cause a massive subgaleal haemorrhage.[37] Similarly slides are now attached to mounds or natural slopes.

On the other hand, monkey bars or horizontal ladders seem to offer increased risks to children.[10 31] This is probably because of the upper body strength needed to use them.

HEIGHT AND SURFACE

The height that a child can fall, the surface fallen to, and the interaction of the two have been identified as contributing to injury related to playground equipment. Standards in the USA, Canada, and Australia, recognise a nexus between the two and have produced standards for the measurement of the impact attenuation properties of different surfaces.[4 36] This approach has the advantage of objective measurement and/or moving the debate from suitability of different types of loose fill surface to what is a suitable level of measurement to prevent or reduce injury. Compliance of a surface can be measured with consideration of the height of the equipment, and the impact attenuation properties of the surface. The measure used is a calculated head injury criterion (HIC) derived from forces measured in adult seat belt experiments decades ago. Recent findings linking accelerometer testing of surfaces with injuries to children following falls from horizontal ladders suggest that the levels of 200 g (or HIC 1000) are not sufficient to be protective for fractures, and that the standards in USA, Australia, and Canada might need to be revisited as further data on real injuries from real falls become available (Nixon *et al*, unpublished data). Chalmers[12] estimated some 10% of attendances at hospital following playground injury were attributable to non-complying surfaces, while 5.6% were attributed to the interaction between the surface and the height of the equipment.

INTERVENTION STUDIES

There have been only two intervention studies on playground injuries reported in the literature. An intervention in Cardiff increased bark depth in five playgrounds and replaced monkey bars with a rope climbing frame in one of them. These playgrounds were compared with 14 others, where no changes were made. There were significantly fewer injuries when taken as a whole, and in the playground where the monkey bars were replaced. The reduction in injuries in the four playgrounds where just the bark depth was increased was not significant. This was essentially an opportunistic study; the Council was making changes which were able to be monitored.

The other study was a community intervention trial in New Zealand[8] where 24 schools were randomised to a programme to encourage them to improve playground hazards at schools. The programme was effective.

EXPOSURE OF CHILDREN TO RISK

Three measures of exposure to playground surfaces and play have been reported. Injuries to children in childcare centres in Atlanta have been expressed as injuries per 100 000 hours spent in childcare.[26]

Another approach to exposure used number of children and time spent playing over different play surfaces.[9] The measure translated into an injury rate over grass of 12/10 000 child years. A third method of determining "exposure" was to count the number of children playing in each park visited by park inspectors.[11] This measure, while convenient, assumed that all play equipment was used equally by the children in the park, and examined children playing over different surfaces rather than the equipment played on. Recent studies in Australia[38] show that children exhibit different levels of play on different types of equipment and in the different settings of parks and schools.

From observation studies each horizontal ladder was used 2.6 times more often than each piece of climbing equipment in schools, while each horizontal ladder was used 7.8 times more than each piece of climbing equipment in a sample of public parks. Slides were used 4.6 times more than climbing equipment in parks and 1.2 times more in public schools.

PLAY VALUE VERSUS SAFETY

Two interests have been identified in educational literature: the need for safety in the playground, and the need to provide a variety of developmental and educational experiences for children. The risk of playground injury is small among preschool children; understandably the main focus for this group is on play experience, and safety advice is directed at supervision and surfaces.[39 40] While some level of supervision is expected in schools, playgrounds in public parks cater for a much wider age range among children, and there is little or no supervision.

Children's outdoor play in schools has also been reported to be under threat. Reasons put forward include the following: the time could be better spent on academic pursuits; playground injuries promote litigation; children are at an increased risk of coming in contact with threatening strangers; and teachers and volunteers are less willing to supervise play activities. The value of play to children's physical and mental development is not challenged; however, it must also be balanced with the child's right for minimal risk to disabling injury.[41] Head injury or serious fractures with lifelong consequences should not be considered part of growing up.

PLAY MORTALITY

Although injuries are the leading cause of mortality for children over 1 year of age, all the evidence is that very few children die in playgrounds.[43 44] A review of the CHIRPP database (Canada) by Lillis *et al* during 1990–91 did not identify any fatal playground accidents.[27] Chalmers' study in New Zealand placed the risk at 0.15/100 000 for playground related death.[12] In the northern hemisphere Ball and King assumed one death per annum (1985) in the United Kingdom.[22]

There have been a number of reports[45 46] from the United States based on data from the Consumer Product Safety Commission, the most comprehensive being published in 2001.[47] From January 1990 to August 2000, CPSC received reports of 147 deaths to children younger than 15 that involved playground equipment (15 per annum). In the 128 incidents for which the location was reported, 90 (70%) occurred in home locations and 38 (30%) in public playgrounds. Over half of these deaths involved unintentional hanging, primarily from ropes, shoestrings, clothing, or homemade swings. A review of the DTI/LASS (UK) database from 1978 to 2000 did not reveal any deaths coded to playground sites. Although accidents are a leading cause of mortality in childhood, the risk of playground death is small. The predominant cause of death in the current literature is strangulation, rather than head injury due to falls or collision.

THE WAY FORWARD AND CONCLUSIONS

Injuries to children in playgrounds is a complex subject. They are many factors that influence them, including the environment of the playground, the behaviour of the child, and frequency of use. This article has focused mainly on environmental factors.

Many of the studies that have investigated playground injuries have described overall injuries. This may have resulted in insufficient focus on the injuries that really matter: those to the head and fractures. A historical review implies that there were serious head injuries before the introduction of modernisation and safety surfacing. Indeed the prevention of head injuries was the reason why safety surfacing was introduced. There are very few head injuries now in modern playgrounds. We therefore believe that safety surfacing is likely to be effective in preventing head injuries and should be continued.

There is also evidence that safety surfacing has prevented overall injuries. However, it does not seem to protect against fractures of the arm. The next step therefore should be to develop surfaces that protect against limb fractures while not compromising safety from head injury.

There are difficulties in implementing intervention studies to prevent playground injuries. There needs to be a cooperative local council (or school). Changes are unlikely to be made just for a scientific study. Despite these difficulties, there are unanswered questions about playground injuries, and further well designed studies will be needed to continue to reduce the risk of injuries in playgrounds. This will require ongoing surveillance.

Although there are still challenges, particularly the prevention of arm fractures, modern playgrounds are safer now than they were 35 years ago. They are still popular with children and mostly provide good play experience for them. They do not need fall heights of over 4 metres, and concrete surfaces to be exciting for children. If they are seen to be safe by parents, they will allow their children to play. This will mean safety for the children and good play experience as well.

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Authors' affiliations
C Norton, J R Sibert, Department of Child Health, University of Wales College of Medicine, Llandough Hospital, Penarth CF64 2XX, Wales, UK
J Nixon, Department of Child Health, University of Queensland, Paediatrics and Child Health, Royal Children's Hospital, Herston, QLD 4029, Brisbane Australia

Correspondence to: Prof. J R Sibert, Department of Child Health, University of Wales College of Medicine, Llandough Hospital, Penarth CF64 2XX, Wales, UK; sibert@cf.ac.uk

APPENDIX

Search strategy

- Electronic bibliographic databases. Medline via OVID (1966–2000), Premedline 2001, Embase, Cinahl, Science citation index, Health Star.
- Reference list review of key papers.
- Hand searching key journals, e.g. *Injury Prevention*.
- Grey literature review via SIGLE (System for information on Grey literature), HMIC (Health Management Information Consortium) CD-ROM.
- National Research register review.
- Manufacturers and trade organisations —ILAM, Playing Fields Association.
- Internet sites, e.g. CPSC (Consumer Product Safety Commission).

Search terms employed

Playgrounds or play* or leisure or monkey bars or swings or slides or ''climbing frames'' and Injuries or fall or fracture or accident and Prevention or prevent* or surfaces or surface*.

Inclusion criteria

All study designs were initially considered. Papers referring to public, school, and home/improvised playground equipment were included. Papers that did not include injury data and referred to risk or compliance with regulations were excluded. Papers referring to sport play activities not involving playground equipment and purely behavioural studies were excluded.

Papers with a more restricted focus, such as epidemiology of head injury or fracture were retained for information and reference review.

Papers were selected that provided information on injuries incurred by children in a playground setting. Papers with a more restricted focus, such as epidemiology of head injury were retained for information and reference review.

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