ARM FRACTURE IN CHILDREN'S FALLS

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INTRODUCTION

Arm fractures in children are a significant public health problem in New Zealand and other industrialized nations. Computer simulation has been used to model the risk of arm fracture in children as a function of fall height, surface stiffness and damping, child age and fracture history; taking into account physical properties of children such as body weight, arm stiffness, bone density and bone size [1]. This 'biomechanical impact model' generated a 'Factor of Risk' (FR) ratio of the impact force to the fracture force. The model was validated using data gathered for an epidemiological case-control study of falls from playgrounds [2]. The FR values were found to be significantly associated with the actual fracture probability (FP) and an 'injury risk curve' was generated to predict fracture probabilities for given values of FR [3]. The purpose of the current study was to use the biomechanical impact model and the injury risk curve to predict distal radius fracture for a series of playground fall scenarios. This study assessed the risk relationship between child age, equipment heights and surfaces currently used in playgrounds in New Zealand and other countries with the aim of providing information on which to recommend measures for reducing arm fractures in falls from playground equipment.

METHODS

Playground fall scenarios were defined by child age (5, 9 and 13.5 years of age), fall height (0.5 to 3m at 0.5 m intervals), and surface type. The surface types are listed in Table 1. These scenarios were chosen to represent the range of fall situations that are expected to be encountered at typical playgrounds. FR values were generated for each of the fall scenarios using the biomechanical model, with FR being the estimated impact force (based on the child's age and mass; fall height and surface impacted) divided by the estimated fracture force (based on the child's age and fall height dependent strain rate). The biomechanical model is a rheological two-mass model with the wrist and shoulder joints represented as linear spring and damper elements [1, 4]. The impact properties of childrens' joints were derived from a gymnastic study of head-first wrist impacts [5] and surfaces were modeled as linear or exponential springs [3]. Presented here are analyses conducted for the high-frequency force component representing the initial hand impact. FP values as a function of FR were derived from the injury risk curve (Figure 1) [3].

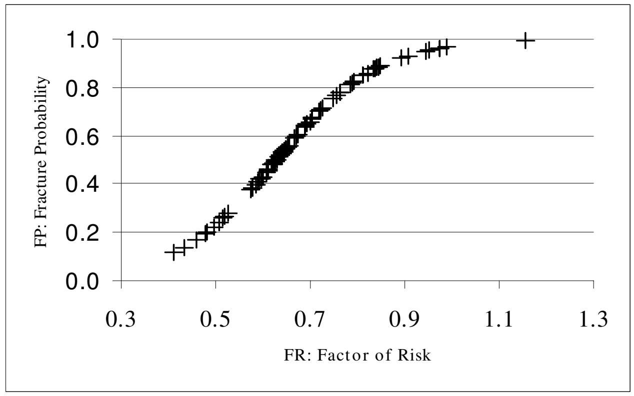

Figure 1: Injury Risk Curve [3].

RESULTS AND DISCUSSION

The fall scenarios for a child aged 9 are listed in Table 1. Surfaces are listed in order of decreasing risk. Earth, grass, rubber mats and dry 15cm deep bark chips produced very similar risks. Wet bark produced a lower risk compared to dry bark, likely due to an increased energy absorbing capacity. The scenarios for ages 5 and 13.5 years of age produced similar pattern of results but with lower and higher values respectively, compared to 9 years of age. Risk increased dramatically with fall height with 3m falls having a high probability of arm fracture. Due the limitations of the case-control study upon which the injury risk curve was based; the model is limited to falls onto a single arm and that are serious enough to require attention (medical or reassurance) by a caregiver.

CONCLUSIONS

This study showed that non-rigid surfaces typically used playgrounds give similar risks of fracture and this risk reached high values for 3m fall heights. This study demonstrates how the biomechanical model is a valuable tool in evaluating interventions aimed at reducing arm fractures in children.

REFERENCES

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Table 1: FP values as a function of fall height and surface type for a child 9 years of age (D: dry; W: Wet; 15 & 30: cm depths)

Fall Height (m)	Impact Surface Type							
	Rigid	Earth	Grass	RubberMat	Bark D15	Bark W15	Bark D30	Bark W30
0.5	0.16	0.11	0.11	0.10	0.09	0.08	0.08	0.06
1.0	0.45	0.30	0.29	0.28	0.25	0.23	0.22	0.17
1.5	0.71	0.55	0.54	0.52	0.50	0.44	0.41	0.32
2.0	0.86	0.73	0.74	0.71	0.70	0.64	0.59	0.49
2.5	0.94	0.87	0.87	0.84	0.82	0.78	0.74	0.66
3.0	0.96	0.93	0.93	0.91	0.90	0.87	0.83	0.77