



Impact sites representing potential bruising locations associated with bed falls in children

Raymond Dsouza¹, Gina Bertocci*

Injury Risk Assessment and Prevention (iRAP) Laboratory, Bioengineering Department, University of Louisville, KY, USA

ARTICLE INFO

Article history:

Received 25 May 2017

Received in revised form 15 December 2017

Accepted 18 February 2018

Available online xxx

Keywords:

Bruising

Biomechanics

Child abuse

Injury assessment

Force sensor

Anthropomorphic test device

ABSTRACT

Bruising can occur as a result of accidental or abusive trauma in children. Bruises are an early sign of child abuse and their locations on the body can be an effective delineator of abusive trauma. Since falls are often reported as false histories in abuse, the ability to predict potential bruising locations in falls could be valuable when attempting to differentiate between abuse and accident. In our study we used an anthropomorphic test device (ATD), a surrogate representing a 12 month old child, adapted with a custom developed force sensing skin to predict potential bruising locations during simulated bed falls. The sensing skin is made of custom resistive force sensors integrated into a conformable skin, adapted to fit the contours of the ATD. The sensing skin measured and displayed recorded force data on a computerized body image mapping system when sensors were activated. Simulated bed fall experiments were performed from two initial positions (FF – facing forward and FR – facing rearward) and two fall heights of 61 cm (24 in) and 91 cm (36 in) onto a padded carpet impact surface. Findings indicated potential bruising primarily in two planes of the ATD body. The majority of contact regions and greater forces were recorded in one plane, with fewer regions of contact and decreased force exhibited in an adjoining second plane. Additionally, no contact was recorded in the two planes opposite the impact planes. Differences in contact regions were observed for varying heights and initial position. Limitations of ATD biofidelity and soft tissue properties must be considered when interpreting these findings.

© 2018 Elsevier B.V. All rights reserved.

1. Introduction

Child abuse is the leading cause of trauma-related fatalities in children [1]. In 2015, 75% of child maltreatment fatalities occurred in children younger than age 3 [1]. The rate of child abuse and neglect victims has increased by 3.8% from 2011 (658,000) to 2015 (683,000) in the U.S., resulting in an estimated 1670 deaths in 2015 [1]. However, we cannot be certain of how many child abuse cases go undiagnosed, since 50–80% of fatal or near-fatal abuse cases have evidence of prior injuries [2,3]. Infants (less than 1-year of

age) are the most vulnerable to abuse and have the highest rate of victimization at 24.2 per 1000 children when compared to all age groups [1].

While bruising can occur in accidental trauma, it is a common early sign of abuse in young children, especially those who are non-ambulatory [4]. Number, location, pattern and appearance of bruises have been shown to differ between abusive and accidental trauma [4–8]. The ability to differentiation between accident and abuse based upon bruising characteristics is critical in clinical and forensic settings, as this “roadmap” is indicative of a child's exposure to impact. Each bruise represents an impact and must be accounted for in the provided history to confirm compatibility between bruising patterns and stated cause. Determining compatibility is a critical part of the diagnostic and forensic assessment process, and can potentially prevent abused children from being returned to an unsafe environment where they may experience escalating or fatal abuse. Conversely, confirmation of compatibility could prevent innocent families from being wrongly accused of abuse.

The capability to predict potential bruising locations associated with common household falls which are often reported as false histories in child abuse does not exist and could prove useful in the

Abbreviations: ATD, anthropomorphic test device; FF, facing forward; FR, facing rearward; FF61, facing forward with a fall height of 61 cm (24 in); FF91, facing forward with a fall height of 91 cm (36 in); FR61, facing rearward with a fall height of 61 cm (24 in); FR91, facing rearward with a fall height of 91 cm (36 in); SBDS, surrogate bruising detection system; VI, virtual instrument; ANOVA, analysis of variance.

* Corresponding author at: Room 204 Health Sciences Research Tower, 500 S. Preston St, Louisville, KY 40202, USA.

E-mail addresses: raymond.dsouza@louisville.edu (R. Dsouza), gbertocci@louisville.edu (G. Bertocci).

¹ Address: Room 110 Instructional Building B., 500 S. Preston St, Louisville, KY 40202, USA.



Fig. 1. CRABI anthropomorphic test device (ATD) in side-lying, facing forward initial position for bed fall experiments. The pendulum actuator (providing the initial force to the posterior torso of the ATD to initiate the fall) is located behind the ATD.

distinction between abusive and accidental injuries. Thus, the goal of our study was to characterize potential bruising locations or patterns associated with a common childhood fall. In this study we used a bruising detection system to identify potential bruising patterns in simulated bed falls employing a child surrogate representative of a 12-month old child (stage of early independent mobility). The bruising detection system consisted of a pediatric anthropomorphic test device (ATD) equipped with a custom force sensing skin that is linked to display recorded force data on a computerized body mapping image system when the force sensors are activated [9]. Our intent was to document a “roadmap” of the surrogate’s contact exposure during bed falls and to identify whether variations in fall parameters (fall height and initial position) led to differences in impact locations or patterns.

2. Methods

The surrogate bruising detection system (SBDS), consisting of the 12 month old CRABI ATD (10 kg mass) fitted with a force sensing skin and associated data acquisition hardware and analysis software, was used to predict potential bruising patterns in simulated fall scenarios. The sensing skin of the SBDS consists of 132 force sensors enveloping the surface of the ATD that is divided into seven regions including the head, anterior torso, posterior torso, forearm, upper arm, thigh and shank. Each region has individualized custom sensor arrays. Graphical programming software² was used to acquire and display sensor output in a manner that relates sensor location to body region. Additional details of the SBDS and its individual components are described in earlier publications [9,10].

The SBDS was used to assess potential bruising locations on the body during a series of bed fall experiments as this type of furniture fall is commonly experienced by young children.

Table 1
ATD initial joint angles.

Joint	Angle (degrees)
Right shoulder extension	135°
Right elbow extension	110°
Left shoulder extension	0°
Left elbow extension	170°
Hip (both) flexion	50°
Knee flexion	80°

2.1. Test setup

The ATD was placed in a side-lying position on the edge of a horizontal surface representing a couch or bed (Fig. 1). A swinging pendulum actuator supported by a tripod with a manually operated release mechanism was positioned at the ATD posterior mid-torso (approximate center of mass). The pendulum actuator consisted of a weight (2.5 kg) that was released (by a manually operated release mechanism) from its raised position (angle of 30° to the vertical) such that the weight made contact with the same location on the ATD torso. The pendulum actuator provided a consistent initial force sufficient to initiate roll of the ATD from the bed surface and fall freely under the effects of gravity. Fall experiments were conducted using two different initial conditions and two different bed heights. The impact surface for all the falls was padded carpet over a wooden subfloor.

Prior to each fall, ATD joint angles were adjusted using a goniometer to ensure repeated positioning in all tests (Table 1). Additionally, joint stiffness was calibrated to manufacturer specifications whereby the joints were tightened until the friction was just sufficient to support the weight of the limb against gravity. The impact surface evaluated for all fall scenarios was padded carpet over a wooden subfloor. The carpet surface consisted of a 1.3 cm (1/2 in) thick open loop carpet placed over 1.0 cm (3/8 in) thick foam padding. The carpet and padding were placed over a 1.9 cm (3/4 in) thick plywood platform 183 cm × 91.5 cm (6 ft × 3 ft) built to standard building codes with 5.1 cm × 10.2 cm (2 in × 4 in) joists, spaced 40.6 cm (16 in) on center.

2.2. Data acquisition and analysis

The SBDS’s sensors consist of force sensing resistors whose outputs were fed to the data acquisition system through a voltage divider circuit to convert resistance to voltage. Data acquisition hardware³ was used to capture and convert the analog sensor output. Multifunctional input/output data acquisition cards⁴ (Resolution – 16 bit, Sample rate – 250 kS/s) acquired, conditioned and digitized the sensor output signals. The National Instruments PCI-6225 data acquisition card is capable of measuring 80 single ended analog channels at a 16 bit resolution and a sample rate of 250 kS/s. A personal computer served as the platform for the data acquisition hardware.

Graphical programming software⁵ was used to acquire and display sensor output in a manner that relates sensor location to body region. A Virtual Instrument (VI) was developed to accomplish this objective. An active 3D (3-dimensional) body map image representing the ATD served as a graphical interface and was developed using Labview (National Instruments) software. The body image was discretely mapped to the sensors on the ATD such that active sensor outputs (those which have been

² Labview 2010; National Instruments, Austin, TX, USA.

³ National Instruments, TX, USA.

⁴ PCI – 6225; National Instruments, TX, USA.

⁵ Labview 2010; National Instruments, TX, USA.

Download English Version:

<https://daneshyari.com/en/article/6551106>

Download Persian Version:

<https://daneshyari.com/article/6551106>

[Daneshyari.com](https://daneshyari.com)