EXPLICO
ENGINEERING

SIERRA TANKERSLEY CASE

Biomechanical Analysis

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MICHIGAN STATE
UNIVERSITY

COLLEGE OF
ENGINEERING

Drexel
UNIVERSITY

DREXEL UNIVERSITY
School of
Biomedical
Engineering, Science
and Health Systems

METHODOLOGY??

Reference Manual on
Scientific Evidence

Second Edition

Federal Judicial Center 2000

Reference Manual on
Scientific Evidence

Third Edition

Committee on the Development of the Third Edition of the Reference Manual on Scientific Evidence

Committee on Science, Technology, and Law Policy and Global Affairs

FEDERAL JUDICIAL CENTER

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Foreword

In 1993, in the case *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the Supreme Court instructed trial judges to serve as "gatekeepers" in determining whether the opinion of a proffered expert is based on scientific reasoning and methodology. Since *Daubert*, scientific and technical information has become increasingly important in all types of decisionmaking, including litigation. As a result, the science and legal communities have searched for expanding opportunities for collaboration.

Our two institutions have been at the forefront of trying to improve the use of science by judges and attorneys. In *Daubert*, the Supreme Court cited an *amicus curiae* brief submitted by the National Academy of Sciences and the American Association for the Advancement of Science to support the view of science as "a process for proposing and refining theoretical explanations about the world that are subject to further testing and refinement." Similarly, in *Kumho Tire Co. v. Carmichael* (1999) the Court cited an amicus brief filed by the National Academy of Engineering for its assistance in explaining the process of engineering.

Soon after the *Daubert* decision the Federal Judicial Center published the first edition of the *Reference Manual on Scientific Evidence*, which has become the leading reference source for federal judges for difficult issues involving scientific testimony. The Center also undertook a series of research studies and judicial education programs intended to strengthen the use of science in courts.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

THE FEDERAL JUDICIAL CENTER

The Federal Judicial Center is the research and education agency of the federal judicial system. It was established by Congress in 1967 (28 U.S.C. §§ 620–629), on the recommendation of the Judicial Conference of the United States, with the mission to "further the development and adoption of improved judicial administration in the courts of the United States." By statute, the Chief Justice of the United States chairs the Federal Judicial Center's Board, which also includes the director of the Administrative Office of the U.S. Courts and seven judges elected by the Judicial Conference.

The Center undertakes empirical and exploratory research on federal judicial processes, court management, and sentencing and its consequences, often at the request of the Judicial Conference and its committees, the courts themselves, or other groups in the federal system. In addition to orientation and continuing education programs for judges and court staff on law and case management, the Center produces publications, videos, and online resources. The Center provides leadership and management education for judges and court employees, and other training as needed. Center research informs many of its educational efforts. The Center also produces resources and materials on the history of the federal courts, and it develops resources to assist in fostering effective judicial administration in other countries.

Since its founding, the Center has had nine directors. Judge Barbara J. Rothstein became director of the Federal Judicial Center in 2003

www.fjc.gov

Figure 1 provides examples of the diverse types of information that may be available for review in determining external causation. In any given case, much of the listed information is normally not available.[111] Determining external causation also generally occurs in a stepwise fashion. In the first step the physician must establish the characteristics of the medical condition. Second, he or she carefully defines the nature and amount of the environmental exposure. The third step is to demonstrate that the medical and scientific literature provides evidence that in some circumstances the exposure under consideration can cause the outcome under consideration. This step is synonymous with establishment of general causation. As part of this step, the clinician attempts to establish the relationship between dose and response, including whether thresholds exist, ultimately defining the clinical toxicology of the exposure. The fourth step is to apply this general knowledge to the specific circumstances of the case at hand, incorporating the specifics of exposure, mitigating or exacerbating influences, individual susceptibilities, competing or synergistic causes, and any other relevant data.[112]

simple silicosis is much more commonly a chronic illness resulting from years of exposure.[123] In other situations, exposure estimates will be based on methods beyond the scope of medical expertise, such as physical or chemical analyses, or chemical fate-and-transport modeling (i.e., using mathematical models to project the movement of chemicals in air, water, and soil).

Specifically, one cross-disciplinary domain deals with the study of injury mechanics, which spans the interface between mechanics and biology. The traditional role of the physician is the diagnosis (identification) of injuries and their treatment, not necessarily a detailed assessment of the physical forces and motions that created injuries during a specific event. The field of biomechanics (alternatively called biomechanical engineering) involves the application of mechanical principles to biological systems, and is well suited to answering questions pertaining to injury mechanics. Biomechanical engineers are trained in principles of mechanics (the branch of physics concerned with how physical bodies respond to forces and motion), and also have varying degrees of training or experience in the biological sciences relevant to their particular interest or expertise. This training or experience can take a variety of forms, including medical or biological coursework, clinical experience, study of real-world injury data, mechanical testing of human or animal tissue in the laboratory, studies of human volunteers in non-injurious environments, or computational modeling of injury-producing events.

engineering fields, the basic sciences or even may have a medical degree. The court's role as gatekeeper requires an evaluation of an individual's specific training and experience that goes beyond academic degrees. In addition to academic degrees, practitioners in biomechanics may be further qualified by virtue of laboratory research experience in the testing of biological tissues or human surrogates (including anthropomorphic test devices, or "crash-test dummies"), experience in the reconstruction of real-world injury events, or experience in computer modeling of human motion or tissue mechanics. A record of technical publications in the peer-reviewed biomechanical literature will often support these experiences. Such an expert would rely on medical records to obtain information regarding clinical diagnoses, and would rely on engineering and physics training to understand the mechanics of the specific event that created the injuries. A practitioner whose expe-

INJURY CAUSATION STEPS

- Characterize Exposure
- Characterize Medical Condition
- In general, can exposure cause outcome? (based on literature)
- Application to Subject Incident

Reference Manual on Scientific Evidence

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FEDERAL JUDICIAL CENTER

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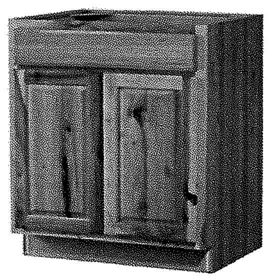
Interrogation



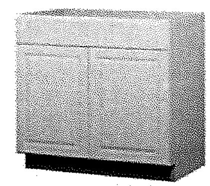
Kitchen Classics Denver 30-in W x 35-in H x 23.75-in D Finished Hickory Door and Drawer Base Cabinet

Item #: 189329 | Model #: 28 B30

★★★★★ 2 reviews | Write a review

$234.00

Facebook Pinterest Twitter Google+ Email



Kitchen Classics Concord 36-in W x 35-in H x 23.75-in D Finished White Door and Drawer Base Cabinet

Item #: 53019 | Model #: 23 B36B

★★★★★ 4 reviews | Write a review

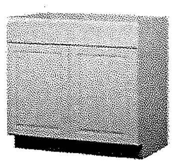
$208.80

NEW LOWER PRICE

Was: $232.00

Save 10%

Demo



Kitchen Classics Concord 36-in W x 35-in H x 23.75-in D Finished White Sink Base Cabinet

Item #: 53092 | Model #: 23 SB36B

★★★★★ 2 reviews | Write a review

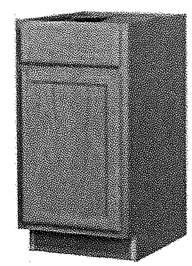
$148.50

NEW LOWER PRICE

Was: $165.00

Save 10%

Facebook Pinterest Twitter Google+ Email

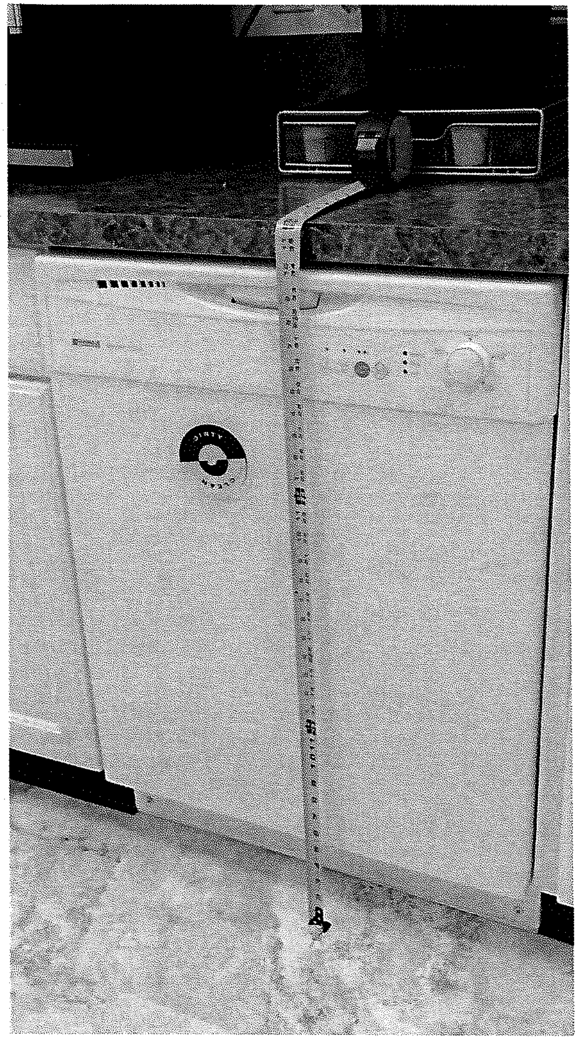


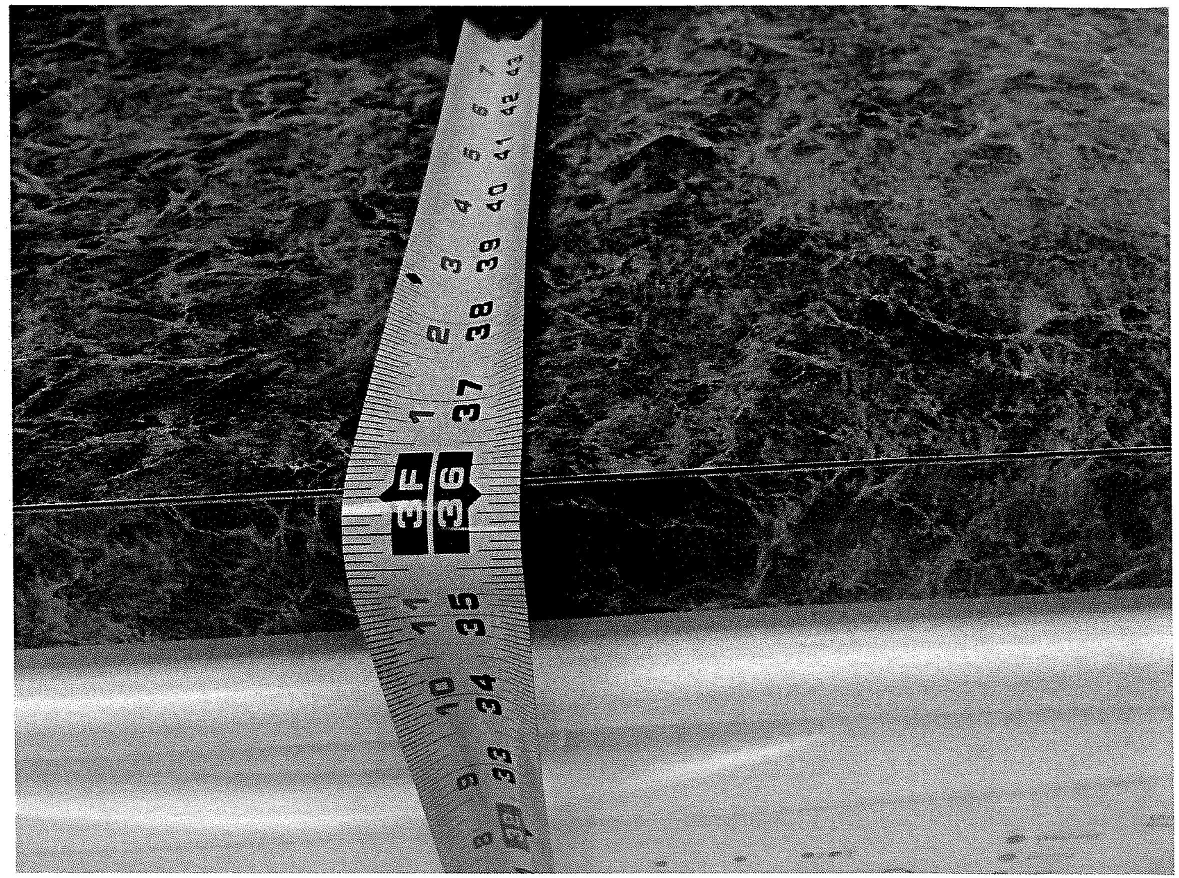
Kitchen Classics 18-in W x 35-in H x 23.75-in D Unfinished Oak Door and Drawer Base Cabinet

Item #: 336273 | Model #: 33 B18R

★★★★★ 1 review | Write a review

$82.83



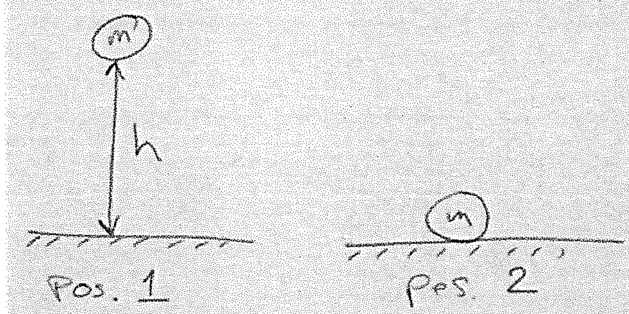


Verification

Laws of Physics: Conservation of Energy

Determining Speed of Falling Object at Impact

FALL HEIGHT DERIVATION



ENERGY @ Pos. 1 = Pos. 2

$$mgh_1 + \frac{1}{2}mv_1^2 = mgh_2 + \frac{1}{2}mv_2^2$$

mass doesn't change & therefore all cancel

$$gh_1 + \frac{v_1^2}{2} = gh_2 + \frac{v_2^2}{2}$$

$$h_2 = 0 \text{ \& } v_1 = 0$$

$$gh_1 = \frac{v_2^2}{2}$$

$$v_2 = \sqrt{2gh}$$

$$V_{impact} = \sqrt{2gh}$$

$g = 32.2\ ft/s^2$

$h = 36$ inches $= 3$ feet

$$V_{impact} = \sqrt{2 \cdot 32.2 \cdot 3}$$

$= 13.9\ ft/s$

$= 9.5$ mph

@ 48 inches = 4 feet

$= 10.9$ mph

Anthropomorphic simulations of falls, shakes, and inflicted impacts in infants

Michael T. Prange, Ph.D., Brittany Coats, B.S., Ann-Christine Duhaime, M.D., and Susan S. Margulies, Ph.D.

Department of Bioengineering, University of Pennsylvania, Philadelphia; and Division of Neurosurgery, Children's Hospital of Philadelphia, Pennsylvania

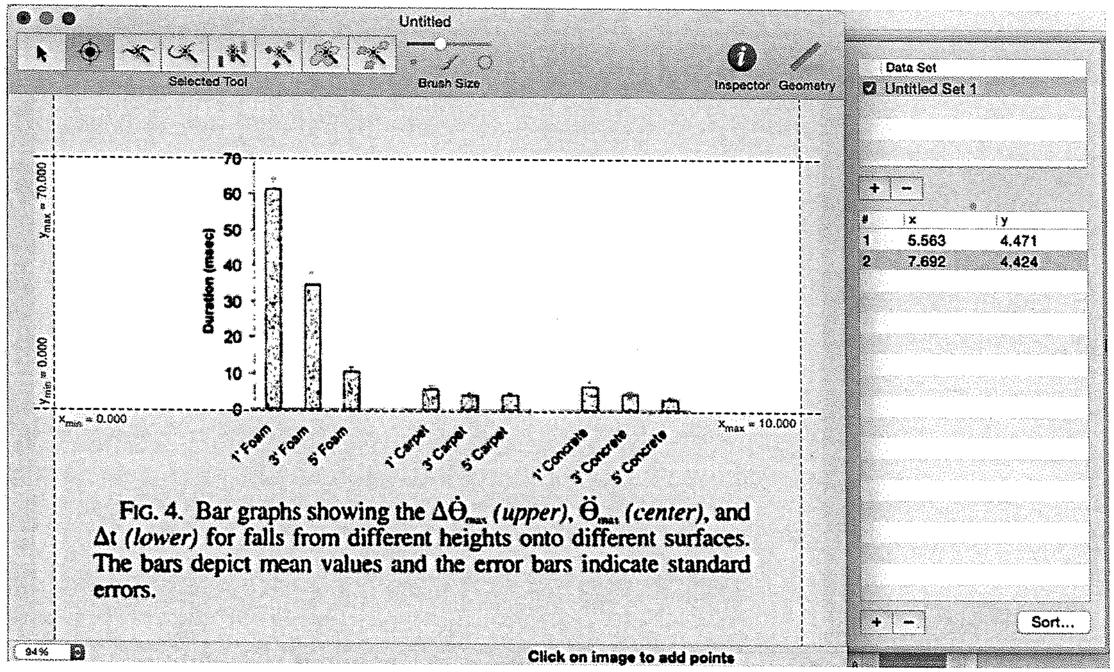
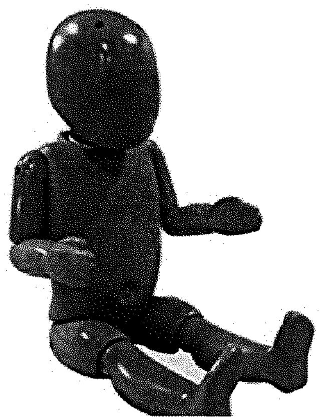


FIG. 4. Bar graphs showing the $\Delta\dot{\Theta}_{max}$ *(upper)*, $\ddot{\Theta}_{max}$ *(center)*, and Δt *(lower)* for falls from different heights onto different surfaces. The bars depict mean values and the error bars indicate standard errors.

CRABI 12 Month Old Child Dummy

Available Product Lines

- 921022-000-H (ATD Assembly)



Overview

The CRABI 12 Month Old was developed by FTSS and Denton to evaluate small child restraint systems in automotive crash environments, in all directions of without air b:

Instrumentation

Test Equipment

Assembly Weights

Part	Weight (kg)	Weight (lbs)
Head	2.64 ± .05	5.82 ± .11
Neck	0.38 ± .03	0.84 ± .07
Torso	3.68 ± .10	8.11 ± .22
Arm, Left or Right	0.60 ± .03	1.32 ± .07
Leg, Left or Right	1.05 ± .03	2.31 ± .07
Total Weight	**10.00 ± .30**	**22.05 ± .66**

Anthropomorphic simulations of falls, shakes, and inflicted impacts in infants

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Department of Bioengineering, University of Pennsylvania, Philadelphia; and Division of Neurosurgery, Children's Hospital of Philadelphia, Pennsylvania

the distribution of the weight of the arms and legs of the infant were incorporated into the weight of the torso. The surrogate's total body weight, 4.8 kg (10.6 lb), was matched to that of a 1.5-month-old infant whose body weight lies within the 50th percentile.[25] Using previously reported measurements, the distributed masses of the head and body were adjusted to mimic those of 1.5-month-old infant by creating a head/total body weight ratio of 0.235[12,25] (1.13-kg head mass). The breadth, length, and width of the head were measured and are in good agreement with those obtained in a 0- to 3-month-old infant in the 50th percentile (Table 1).

Manner of Death:

Homicide

NARRATIVE SUMMARY

Case Number: 11706 - 14
Name: Mayliah Tankersley
Date of Pronounced Death: November 2, 2014
Date of Postmortem Examination: November 3, 2014

The body was that of a normally developed and normally nourished black female, who was received without clothing. A yellow blanket and a black, green, and white blanket accompanied the body in the body bag. The body measured as follows: crown-heel length 72 cm (28 inches) and weighed 9.0 kilograms (20 lbs), and is within the 10 to 25th percentile in weight-for-age and 10th percentile in length-for-age for the stated age of 1 year (13 months 3 weeks calculated from the birth date of 9-11-13). The head circumference measured 45 cm, the chest circumference measured 45.5 cm, and

$$\text{Acceleration} = \frac{\Delta v}{\Delta t}$$

(Δt) Duration of Impact

FROM PRANGE 2003 $\Delta t \approx 5\ \text{msec}$

$$\text{Acceleration}(\vec{a}) = \frac{10\ \text{mph}}{5\ \text{msec}} = 184\ g\text{'s}$$

$$F = m\vec{a}$$

$$= 5\ \text{lb} \cdot 184\ g\text{'s}$$

$$= \underline{\underline{919\ \text{lb}}}$$

$$= 4088\ \text{Newtons}$$

Review

Biomechanics of temporo-parietal skull fracture

Narayan Yoganandan *, Frank A. Pintar

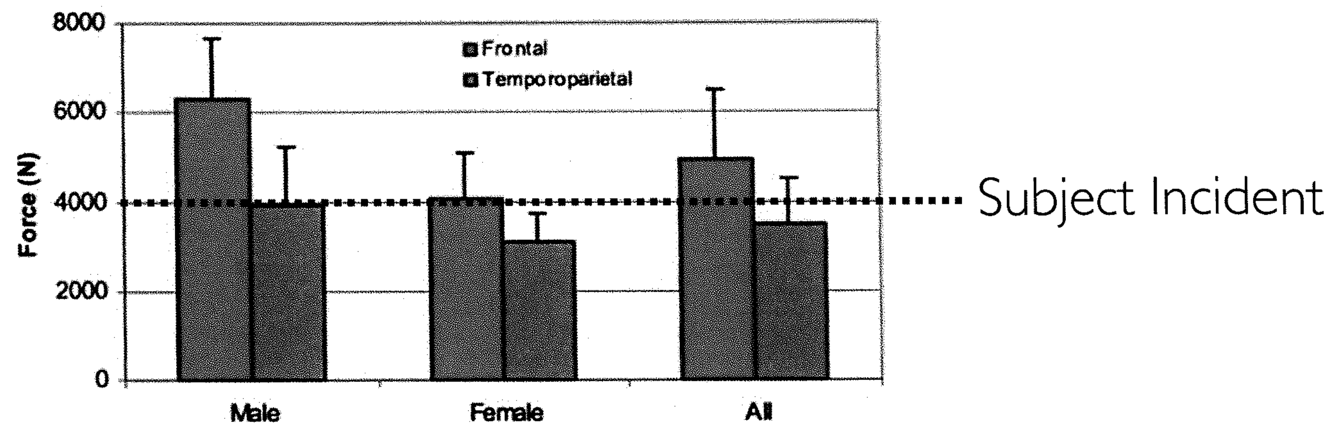


Fig. 5. Mean peak fracture forces (N) as a function of impact site (data from Nahum et al.).

For Adults

IMPACT HEAD INJURY

MECHANISTIC, CLINICAL AND PREVENTIVE CORRELATIONS

By

E. S. GURDJIAN, M.D.

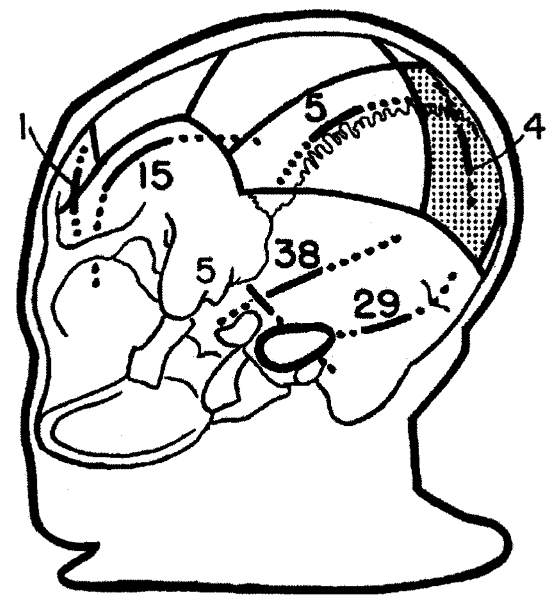
Professor Emeritus
Department of Neurosurgery
Wayne State University
Detroit, Michigan

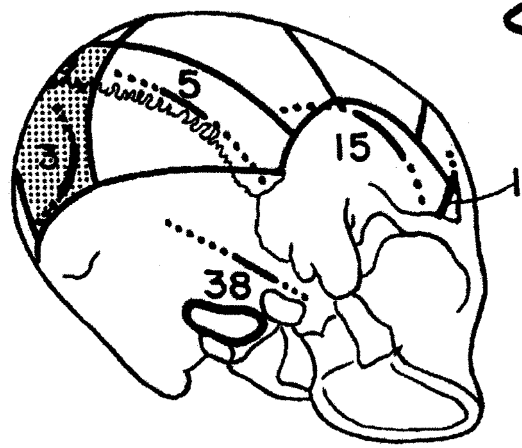
TABLE 6 - III
EXPERIMENTAL SKULL FRACTURE OCCIPITAL DECELERATION IMPACT

No	Energy in Lb	Scalp Thickness (mm)	Weight as Dropped (lb)	Weight Dry (lb)	Distance Dropped (in)	Velocity of Impact (ft/sec)	Race	Fracture*
45	400	5	10.00	1.27	40	14.7	W	111
31	468	8	11.69	1.74	40	14.7	W	11
32	502	6	11.44	1.68	44	15.4	W	1
23	504	7	10.5	1.93	48	16.1	C	11
33	532	8	10.63	1.63	50	16.4	W	1
26	457	3	9.94	1.16	46	15.8	W	11
30	502	6	12.25	1.32	41	14.9	W	11
24	548	4	8.31	1.73	66	18.9	W	11
27	419	3	8.38	1.02	50	16.4	W	111

* Fracture numbers:
1, single linear fracture
11, two linear fractures
111, stellate fractures

MID-OCCIPITAL BLOW





Original Works

Experimental Studies of Skull Fractures in Infants* **

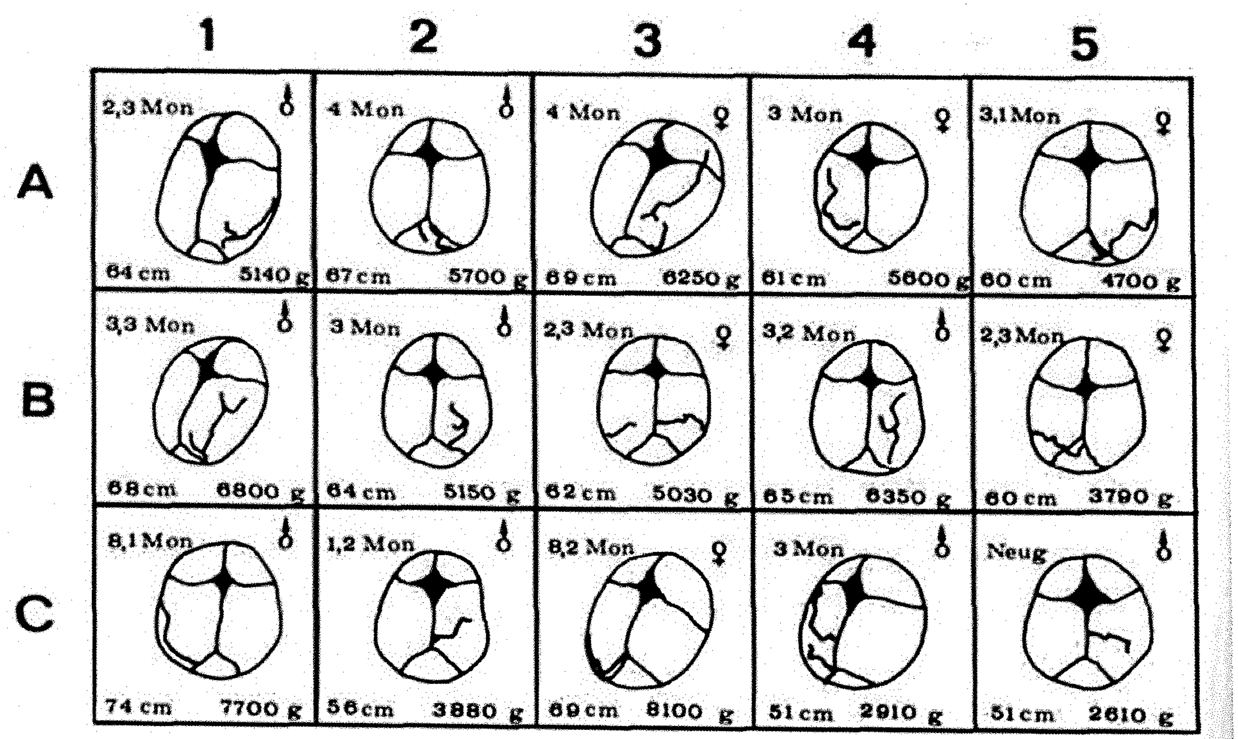
W. Weber

Department of Legal Medicine of the Medical Faculty of the Rhine-Westphalian Technical University of Aachen, Pauwel Street [New Clinic], D-1500 Aachen, Federal Republic of Germany

Experimental Design

The investigative cohort consisted of 15 infants, who had died at ages up to 8.2 months as a result of pathological internal causes. Upon external examination, findings on palpation, and radiography, there was no indication of a previously existing fracture. In three series of 5 cases each the fall took place on a stone-tile floor A, on a carpeted floor B, and on a foam-supported linoleum floor C (Fig, 2), whereby the body in horizontal position and the parieto-occipital region of the skull simultaneously impacted, i.e., without "vis a tergo" [= a propelling force from behind]. Shortly thereafter the collection of investigative findings took place at autopsy.

Even for us the results of the reported experimental fall studies were unexpected. After falls from an 82-cm height—without vis a tergo—calvarial fractures occurred in all 15 infants, in three cases crossing the cranial sutures. Consequently, fissures and fractures of the infant skull are *on principle* to be reckoned with in falls from a diaper-changing table height. Even the clinical absence of symptoms is deceptive and can obviously belie widespread, protected [covered] injuries of the skull. The consequences of the injuries are therefore dependent on the course of the fracture lines, on intracranial and intracerebral hemorrhages (refs.), as well as on posttraumatic cerebral edema.


1
2
3
4
5
A
B
C
2,3 Mon ♂ 64 cm 5140 g
4 Mon ♂ 67 cm 5700 g
4 Mon ♀ 69 cm 6250 g
3 Mon ♀ 61 cm 5600 g
3,1 Mon ♀ 60 cm 4700 g
3,3 Mon ♂ 68 cm 6800 g
3 Mon ♂ 64 cm 5150 g
2,3 Mon ♀ 62 cm 5030 g
3,2 Mon ♂ 65 cm 6350 g
2,3 Mon ♀ 60 cm 3790 g
8,1 Mon ♂ 74 cm 7700 g
1,2 Mon ♂ 56 cm 3880 g
8,2 Mon ♀ 69 cm 8100 g
3 Mon ♂ 51 cm 2910 g
Neug ♂ 51 cm 2610 g

Sports Med
DOI 10.1007/s40279-014-0274-7

REVIEW ARTICLE

Amateur Boxing: Physical and Physiological Attributes

Helmi Chaabène · Montassar Tabben · Bessem Mkaouer · Emerson Franchini · Yassine Negra · Mehrez Hammami · Samiha Amara · Raja Bouguezzi Chaabène · Younés Hachana

Table 4 Maximal punching performance of amateur boxers (data are presented as the mean ± SD)

Athlete characteristics (*n*)	Boxing punch type	Absolute performance (N or kg)	Relative performance (N/kg)	Force measurement equipment	References
English elite-level male boxers (*n* = 29)	Straight lead hand to head	1,722.0 ± 700.0	25.0 ± 9.0	NR	Smith [15]
	Straight rear hand to body	1,682.0 ± 636.0	25.0 ± 8.0		
	Straight rear hand to head	2,643.0 ± 1,273.0	39.0 ± 17.0		
	Straight rear hand to body	2,646.0 ± 1,083.0	39.0 ± 15.0		
	Lead hand hook to head	2,412.0 ± 813.0	36.0 ± 11.0		
	Lead hand hook to body	2,414.0 ± 718.0	35.0 ± 9.0		
	Rear hand hook to head	2,588.0 ± 1,040.0	38.0 ± 13.0		
	Rear hand hook to body	2,555.0 ± 926.0	37.0 ± 12.0		

Values less than 4,000 N (subject incident)